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FAUNA OF THE KIMMSWICK LIMESTONE OF MISSOURI AND ILLINOIS

BY
JOHN H. BRADLEY, JR.

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INTRODUCTION

This paper is concerned primarily with the new species in the fauna of the Kimmswick limestone. The material studied was collected by Dr. Stuart Weller from the vicinity of Glen Park, Missouri, as well as from St. Genevieve County and Cape Girardeau, Missouri; Batchtown, Illinois; and Independence County, Arkansas. This was supplemented by much additional material collected by the writer in the autumn of 1923 near Kimmswick, Sulphur Springs, and Glen Park, Missouri, as well as from Calhoun County, Illinois. The entire collection is preserved in Walker Museum, University of Chicago.

On the basis of the writer's study of these extensive collections, a faunal list for the Kimmswick limestone was drawn up and published.[1] In the same paper the evidence was given for the conclusion that the Kimmswick is of early Trenton rather than late Black River age. Essential contemporaneity was postulated for the Kimmswick and the Prosser of Minnesota, although certain faunal differences suggested the presence of a barrier between the northern and the southern Mississippi Valley in early Trenton times. Evidence was also presented to show that part of the Kimmswick fauna reached the lower Mississippi Valley by way of the Appalachian Valley, whereas another faunule entered from the west.

Because of lack of space, only 51 of the 116 species and varieties described in the original manuscript prepared by the writer can be included in this paper. Of these 35 species and 2 varieties are new to science. With the exception of the trilobites all those species neither new nor especially significant in the Kimmswick fauna have been eliminated. Because the trilobites constitute the dominant and most interesting element of the fauna, all the Kimmswick trilobites known to the writer are here described.

Thanks are due Dr. Stuart Weller for much fine material and for his untiring sympathy and aid throughout the two years during which this study was pursued; to Mr. Arthur Ware Slocom not only for many helpful suggestions but for innumerable services in making illustrations and in preparing the manuscript for the press; to the alumni and members of Kappa Epsilon Pi, whose vigor and generosity have turned the dream of a Walker Museum publication into a reality.

[1] "Stratigraphy of the Kimmswick Limestone of Missouri and Illinois," *Jour. Geol.*, Vol. XXXIII, No. 1 (1925).

DESCRIPTIONS OF GENERA AND SPECIES

Phylum COELENTERATA

Subphylum PORIFERA

Class SPONGIAE

Incertae sedis

Family RECEPTACULITIDAE Roemer

Genus RECEPTACULITES Defrance

RECEPTACULITES CORNUTIFORMIS sp. nov.

PLATE XXIII, FIGURES 5–6

Entire organism horn-shaped, curved, hollow within, at least 10 cm. high and 8 cm. wide at the broad end, ovate in cross-section, body wall thick at closed end, becoming gradually thicker to the base. Ectorhin composed of many close-fitting rhomboidal plates which radiate in longitudinally curved rows from the small end to the peripheral margin of the base, this curvature being sufficient to produce an en échelon arrangement of the plates in the horizontal rows which encircle the shell with a slight convexity toward the open end. The plates near the apex are smaller than those in the middle and widest part of the body. The endorhin is composed of small rhomboidal plates arranged similarly to those of the outer surface, but perforated by small circular or angular orifices at the angles of the plates. The canals of the endorhinal plates cannot be clearly seen in the type of this species. The endorhin and ectorhin are connected by cylindrical spicules, at right angles to the body wall. These spicules appear quite like those of *Receptaculites oweni* Hall, being fastened on the outside to the center of each ectorhinal plate, very slender next to the ectorhin, enlarging to full thickness about one-fourth of the distance between the ectorhin and endorhin, and joining the endorhinal plates without constriction. The body wall is 13 mm. thick near the open end, 11 mm. thick near the middle, and 7 mm. thick near the apex.

Receptaculites cornutiformis sp. nov. is known from a single specimen collected by Professor Stuart Weller near the base of the Kimmswick limestone at Glen Park, Missouri. While agreeing with *R. oweni* Hall in the general composition of the body wall, this species was strikingly different in manner of growth. The body of the former always assumed the form of a broadly expanding disk, and it is not known to have grown in

the shape of a cornucopia. In this connection it is interesting to note that *R. cornutiformis* sp. nov. occurs well below the horizon that carries *R. oweni.*

Horizon and locality: Kimmswick limestone near Glen Park, Missouri.

Phylum MOLLUSCOIDEA

Class BRYOZOA Ehrenberg

Order TREPOSTOMATA Ulrich

Suborder INTEGRATA Ulrich and Bassler

Family HALLOPORIDAE Bassler

Genus HALLOPORA Bassler

HALLOPORA GIGANTEA sp. nov.

PLATE XXIII, FIGURES 2–3

Zoarium ramose, branches subcylindrical, often considerably flattened, dividing irregularly. The diameter of the branches is extremely variable, but in the average examples, exceeds that of all other members of the genus, being 9 or 10 mm. and not infrequently between 15 and 20 mm. in extent. Surface rarely modified by strongly elevated, rounded monticules; in most cases quite smooth. Very few mesopores show at the surface, the zoœcia being normally in contact with each other, angular, and thin-walled, with apertures direct, averaging 3 or somewhat less in 1 mm.

In tangential section the zoœcia are seen to be polygonal, thin-walled, in contact; mesopores practically wanting. In vertical sections the zoœcial tubes are seen to be crowded with diaphragms, the average distance between them being about twice the diameter in the axial region, while near the periphery the diaphragms are more abundant, the width between them being equal to, or less than, the diameter. Diaphragms are curved in the peripheral region, but are nearly straight in the axial region.

Compared with other species of *Hallopora,* this form is easily distinguished by the large diameter of the zoarium as well as the zoœcial tubes. Its relationship to *H. multitabulata* Ulrich is close, but it never has as many diaphragms or as small zoœcial tubes as that species. *H. ampla* Ulrich is similar to *H. gigantea* sp. nov. in the comparative smoothness of its branches, size of zoœcial tubes, and number of diaphragms, but has a narrower peripheral region and more mesopores. Such Black River species as *H. angularis* (Ulrich), *H. goodhuensis* (Ulrich), *H. dumalis* (Ulrich),

H. undulata (Ulrich), and *H. incontroversa* (Ulrich), can readily be distinguished from *H. gigantea* sp. nov. by the smaller size of their branches and zoœcial tubes.

Horizon and locality: Very abundant in the Kimmswick limestone at its contact with the underlying Plattin formation of Cool Spring, one mile south of Batchtown, Illinois; found everywhere in the lower part of the Kimmswick limestone in Calhoun County, Illinois, and Jefferson County, Missouri, becoming less plentiful near the top of the formation.

Order CRYPTOSTOMATA Vine

Family PTILODICTYONIDAE Ulrich

Genus ESCHAROPORA Hall

ESCHAROPORA PATENS sp. nov.

PLATE XXIII, FIGURES 1–4

Zoarium, a single, flattened, unbranching frond, expanding from the point of articulation upward gradually until about midway between the base and the upper margin, whence the expansion is more rapid. The greatest length of the holotype is 87 mm., 75 mm. wide at the top, and 36 mm. wide in the middle; thickness never exceeds 2 mm. and is normally less than 1 mm. About 5 mm. above the rather sharp point of attachment in the holotype, the zoarium by a slight, sudden expansion forms a small shoulder very similar to that observed in *Escharopora maculata* Ulrich from the Maysville. Axial region slightly arched near the base; edges of zoaria thin and in most cases, sharp. Zoœcial walls arranged in regular diagonal intersecting series, which in casts of the interior appear sharply and regularly rhomboidal in outline, but in specimens where the original zoœcial apertures are preserved at the surface, the apertures in many cases lose their sharp rhomboidal outline by a thickening of the interstitial space and become suboval. Measuring transversely there are regularly between 8 and 9 longitudinal rows of zoœcial cells in 2 mm., while the cells within the rows measured diagonally average between 7 and 8 in 2 mm. Surface of the zoarium modified by numerous maculae arranged rather regularly in quincunx, the apices of the maculae being 3 mm. from each other, and somewhat more than 1 mm. in diameter at the base. Cells near the apex of the maculae are slightly enlarged.

This species is closely related to *Escharopora maculata,* agreeing with that species in manner of growth, size and number of maculae, and general arrangement of zoœcia, but differing in being wider at the top and not so long, in having more sharply rhomboidal zoœcial tubes, which are a

little smaller in *E. patens* sp. nov. Compared with *E. pavonia* (d'Orbigny) from the Lorraine of Tennessee and Ohio, the zoarium of *E. patens* sp. nov. expands more regularly, while the zoœcial apertures are more rhomboidal and the maculae are more prominent.

Horizon and locality: Kimmswick limestone at Glen Park, Missouri; near Batchtown, Illinois.

Class BRACHIOPODA Duméril

Order PROTREMATA Beecher

Superfamily ORTHACEA Walcott and Schuchert

Family ORTHIDAE Woodward

Subfamily ORTHINAE Waagen (emend.)

Genus MCEWANELLA Foerste

MCEWANELLA RAYMONDI Foerste

PLATE XXIII, FIGURES 7–8

Mcewanella raymondi Foerste, *Bull. Sci. Lab. Denison Univ.*, XIX (May, 1920), 198, Pl. 23, Fig. 1.

This species was based on a single brachial valve collected by Barton from the Kimmswick limestone near Minke, Missouri. The description states that the valve is

strongly plicated, the crests of the two median plications being only 3 mm. apart and elevated into a median fold which rises 3 mm. above the bordering depressions. The anterior margin of the shell curves backward 5 mm. along this fold, thus indicating the presence of an equally conspicuous sinus on the pedicle valve. On each side of the median fold of the brachial valve there are five lateral plications, of which the first two are conspicuous, the third is of intermediate size, the fourth and fifth are low, and a distance of about 1.5 mm. intervenes between the fifth plication and the hinge-area. The elevation of the first and second plications is about one millimeter, and their crests are rather abruptly rounded. The entire surface is radiately striated. At a distance of about 5 to 10 mm. back from the anterior margin these striae frequently average about 4 in a width of 2 mm., but nearer the anterior margin, where numerous concentric lines of growth indicate gerontic conditions, the number of these striae may increase to 6 in the same width.

The genus *Mcewanella* Foerste, which is peculiar in having the sharply defined radial striations of *Hebertella* combined with the strong plications of *Platystrophia,* is known from *Mcewanella lineolata* (Savage) from the Fernvale of Illinois and Missouri, as well as from *M. raymondi* of the Kimmswick. Both of these species are characterized by their large size, fine radiating striae superimposed upon coarser radial plications, and

by well-defined fold and sinus extending almost to the beaks. The plications in the Kimmswick species are much coarser and the striae more numerous than those of the Fernvale form.

The pedicle valve of *Mcewanella raymondi,* hitherto undescribed, is represented in the collection of Walker Museum by a specimen from the Kimmswick limestone at Cape Girardeau, Missouri, and another from Independence County, Arkansas, both collected by Dr. Stuart Weller. The sinus is as well defined as the fold of the brachial valve; the first lateral plications on both sides of the sinus are the most conspicuous of the four or five plications which diminish in strength from the sinus to the hinge-area. In specimens from the Arkansas Kimmswick, the plications in and near the fold and sinus show a tendency to bifurcate near the middle of the valves. In the pedicle valve from Arkansas the two strong, simple plications which normally occupy the sinus bifurcate to form two smaller plications on the outer sides of the stronger ones. In some specimens the first, and more rarely the second, lateral plications show a tendency to weak bifurcation on their inner sides, but the plications farther from the fold and sinus are always simple.

MEASUREMENTS

	Mm.	
Brachial valve:		
Width	26	
Length	20	
Convexity	9	(after Foerste)
Pedicle valve:		
Width	26.4	
Length	15	
Convexity	12	

Horizon and locality: Kimmswick limestone at Minke and Cape Girardeau, Missouri; O'Flynn Mine, Independence County, Arkansas.

Superfamily STROPHOMENACEA Schuchert
Family STROPHOMENIDAE King
Subfamily RAFINESQUININAE Schuchert
Genus RAFINESQUINA Hall and Clarke

RAFINESQUINA JEFFERSONENSIS sp. nov.

PLATE XXIV, FIGURES 1–6

Shell of medium to large size, semielliptical, usually wider than long, hinge line equal to, or greater than, the greatest width, cardinal angles

rectangular, lateral margins slightly convex, rounding anteriorly. Brachial valve concave anteriorly, becoming flatter in the cardinal and umbonal regions, beak very small, projecting only slightly. Adductor muscle scars are deeply impressed near the cardinal process, separated by a mesial ridge, bounded laterally by thickened ridges, which diverge a little anteriorly. Pedicle valve gently and evenly convex in young specimens, becoming more strongly elevated with age in the umbonal region, and with a somewhat stronger curve to the anterior margin. Diductor muscle scars very large, flabellate, inclosing a long, narrow, thickened adductor scar, Costae typical of the genus, but exceptionally fine, alternating, crossed by fine concentric lines of growth.

This is one of the most common fossils at all horizons of the Kimmswick limestone and is particularly abundant in a zone 10–15 feet above the base of the formation south of Batchtown, Illinois, where the shells of this brachiopod make up most of the bulk of the rock. This species has generally been included in the synonymy of *Rafinesquina alternata* (Emmons), but on critical comparison with the original figure of Emmons[1] and with specimens from the typical locality in the Trenton limestone near Watertown, New York, *R. jeffersonensis* is seen to differ in the following respects:

1. Mature shells are smaller than those of *R. alternata.*

2. The strongly deflected anterior margin of mature examples of *R. alternata* is only occasionally met with in *R. jeffersonensis.*

3. Costae are noticeably alternating in both species, but are considerably coarser in *R. alternata.*

4. The two divisions of the cardinal process are not so distinctly divergent in *R. jeffersonensis.*

5. The outer thickened ridges bounding the adductor muscle scars of *R. alternata* diverge considerably; in *R. jeffersonensis* these ridges are subparallel or they diverge but slightly.

R. jeffersonensis can generally be distinguished from *R. minnesotensis* (N. H. Winchell) on a basis of the stronger convexity and smaller size of the latter; from *R. deltoidea* because of the deltoid outline and greater convexity of that species. Due to the variability of these species, the lines of distinction are in some cases hard to draw with exactness. Most specimens of *R. jeffersonensis* are only moderately convex, but some show variation toward the more convex shell of *R. minnesotensis* and others toward the deflected deltoid shells of *R. deltoidea.*

Horizon and locality: Kimmswick limestone in Jefferson and Ralls counties, Missouri; Calhoun County, Illinois.

[1] *Ind. Ann. Rep. New York Geol. Surv.* (1838), p. 115.

Superfamily PENTAMERACEA Schuchert
Family CLITAMBONITIDAE Winchell and Schuchert
Genus CLITAMBONITES Pander

CLITAMBONITES DIVERSUS (Shaler)

PLATE XXIII, FIGURES 13–15

Orthisina diversa Shaler, *Bull. Mus. Com. Zoöl.*, I (1865), 67.
Orthisina verneuili Billings (not Eichwald), *Cat. Sil. Foss. Anticosti* (1866), pp. 43, 74.
Clitambonites diversa Winchell and Schuchert, *Geol. Minnesota,* III (1893), 378, Pl. 30.
Clitambonites americanus Hall and Clarke, *Pal. New York,* VIII, Part I (1892), 239, Pl. 15A, Figs. 1–8.
For full synonymy, see Bassler, *Bull. 92, U.S.N.M.*

The original description of this species is as follows:

Toothed (pedicle) valve usually pentagonal; socket (brachial) valve quadrate; hinge line usually equal to the greatest width of the shell. Toothed valve very strongly projecting; depth about one-half the width; deepest point about the height of the hinge line; umbo somewhat laterally compressed, usually rising high above the plane of the hinge line, but very variable in this respect; umbo always laterally inclined indifferently towards either extremity of the hinge line. Surface near the extremities of the hinge line a little depressed and slightly recurved; area very large, nearly half as wide as long. Fissure from one fourth to one third the width of the hinge line; deltidium large, massive, rarely central, with distinct circular or oval foramen. Socket-valve with a broad and shallow median fold.

In referring to this brachiopod, Winchell and Schuchert state that this widely-distributed species was first described by Shaler as *Orthisina diversa.* A year later Billings identified it as *O. verneuli* Eichwald, at the same time regarding Shaler's species as synonymous with it. On the other hand, Shaler has since referred *Orthisina verneuili* Billings to his species, in which he is correct. On comparison with the European species, as illustrated by de Verneuil (*Russia and the Ural Mts.*, vol. 2, pl. 11 and 12), it is seen that the American species is wider along the hinge line, the ventral area much less incurved and elevated, with finer striae and a narrow sinus in the dorsal valve. These differences are sufficient to distinguish the two species. Specimens of *Hemipronites americanus* Whitfield have been collected at Oshkosh, Wisconsin, and are found to agree with *Orthisina diversa* Shaler of the Hudson River Group of Anticosti.

Only three specimens of *Clitambonites* are known from the Kimmswick limestone, one collected by D. C. Barton near Mincke, another by Foerste from Ralls County, and the third by the author near Glen Park, Missouri. Foerste's specimen shows the brachial valve, while the other two are well-preserved pedicle valves. On the basis of this limited mate-

rial, the Kimmswick form cannot be differentiated from the Anticosti species. In comparing the specimen from Glen Park with specimens from Anticosti, the former is seen to have a relatively higher cardinal area and steeper descent from the beak to the anterior margin. This, however, is not a sufficient basis for specific distinction, because the Kimmswick specimen is not full grown, and if it be compared with the earlier growth stages of a typical Anticosti specimen the general proportions of the two agree.

Measurements of the two known pedicle valves from the Kimmswick limestone of Missouri are:

	Mm.	Mm.
Height of cardinal area	10	7.2
Width of hinge line	19	14
Greatest width	24	15.8
	(after Foerste)	

Compared with the figures given by Winchell and Schuchert of specimens from the Trenton of Minnesota, the Kimmswick specimens appear to have a relatively higher cardinal area than examples referred to *Clitambonites diversus* (Shaler) and a lower cardinal area than those referred to *C. diversus altissimus* Winchell and Schuchert.

Horizon and locality: Trenton and Richmond of Anticosti; Minnesota, Wisconsin, Ontario, Manitoba, New York. Kimmswick limestone in St. Louis, Ralls, and Jefferson counties, Missouri.

Family PORAMBONITIDAE Davidson

Subfamily PARASTROPHIINAE Schuchert

Genus ANASTROPHIA Hall

ANASTROPHIA PRIMIGENIA sp. nov.

PLATE XXIII, FIGURES 9–12

Shell of medium size, brachial valve very gibbous, pedicle valve almost plane, length slightly exceeding the width. Beak of the brachial valve strongly incurved, covering the foramen of the opposite valve; beak of the pedicle valve very short, only slightly incurved, standing higher than that of the brachial valve. About two-thirds of the distance from the beak to the anterior margin, the brachial valve is rather abruptly deflected, so that the anterior third of the shell is in a plane which is nearly at right angles to the plane of the umbonal region. A broad but very poorly defined fold marks the middle of the brachial valve, best defined on the anterior deflected area, flanked on either side by plications which in rare cases stand slightly higher than the others at the anterior margin. Pedicle valve marked by an equally obscure sinus. The actual lateral limits of

fold and sinus can be determined in many cases only by a study of the juncture of the two valves at the anterior margin, where the serrated line between the valves is abruptly bowed up at the expense of the brachial valves, at the points where fold and sinus merge with the lateral slopes. The width of the fold and sinus is approximately equal to the combined width of the lateral slopes on either side. Surface of both valves covered with strong, simple, sharply rounded plications, 25 to 28 over the entire surface, 8 on the fold of the brachial valve and 7 in the sinus of the pedicle valve. An average specimen is 14.3 mm. long, 15.6 mm. wide, with a convexity of 11.5 mm.

The genus *Anastrophia* Hall, well represented in Silurian and Devonian rocks of North America, England, and Gotland, has hitherto been unknown in the Ordovician. Compared with *A. internascens* Hall from the Niagaran of Kentucky, Indiana, and Wisconsin, the Ordovician form has a more deflected anterior margin, more obscure fold and sinus, with 8 instead of 6 plications on the fold, and 7 instead of 5 in the sinus. In general comparison with later species, *A. primigenia* sp. nov. has a more poorly defined and wider fold and sinus, with the beak of the pedicle valve standing somewhat higher rather than slightly below the beak of the more incurved brachial valve.

Horizon and locality: This species is unknown in the Kimmswick limestone of northeastern Missouri and adjacent regions of Illinois, but is sparingly represented in that formation farther south at Cape Girardeau, Missouri. In Independence County, Arkansas, where the Kimmswick limestone is lithologically and faunally similar to the same formation in Missouri and Illinois, this species is a common fossil, and is associated with *Mcewanella raymondi* Foerste, *Illaenus depressicapitatus* sp. nov., and other Kimmswick fossils.

Phylum MOLLUSCA

Class PELECYPODA Goldfuss

Order PRIONODESMACEA Dall

Superfamily NUCULACEA

Family CTENODONTIDAE Dall

Genus CTENODONTA Salter

CTENODONTA CONCINNA sp. nov.

PLATE XXV, FIGURE 19

Shell small to medium in size, regularly and gently convex, nearly erect, somewhat longer than high, outline of the ventral margin oval, dorsal margin subtriangular. Beaks full, prominent, bluntly pointed, and

slightly incurved; angle between the anterior and posterior cardinal margin at the beaks somewhat more than 90°. Slope anterior to the beaks slightly convex, posterior to the beaks slightly concave. Umbones ventricose, blending with the general surface of the shell which slopes evenly to the margins. Umbonal axis, with a slight forward obliquity, nearer to the anterior than the posterior margin. Surface covered with sharp, fine, concentric lines, evenly spaced, converging to the antero- and postero-dorsal margins, from 16 to 18 in 5 mm. In exceptional cases, concentric folds occur, but the normal shell is without wrinkles. No radiating costae can be detected. A typical specimen is 8 mm. long and 7.8 mm. high.

In comparison with *Ctenodonta intermedia* Ulrich, this species agrees in outline, size, and general style of surface markings, but the concentric lines of *C. intermedia* are coarser (about 12 in 5 mm.) and marked by a fold at intervals of 2 or 3 mm. *C. concinna,* sp. nov. differs from *C. hamburgensis* Walcott in being larger and having striations which cover the entire surface of both valves in equal strength and in lacking the very fine radiating striae of that species. *C. concinna* sp. nov. lacks the coarse growth wrinkles of *C. astartiformis* Salter, which according to Ulrich are a constant feature of the ventral half of the shell in that species.

According to Ulrich's classification of Ordovician Ctenodontas[1] *C. concinna* sp. nov. belongs with the *C. recurva* group, which he characterizes as having

> shells high, the lower half semicircular, the upper subtriangular; hinge plate rather strong, but at nearly a right angle, the (?) anterior part convex, the (?) posterior concave; denticles in two distinct series arranged transversely on the plate and therefore at widely different angles on the two parts of the hinge.

This group falls naturally into two subgroups, one including such species as *C. intermedia* Ulrich, *C. hamburgensis* Walcott, and *C. concinna* sp. nov., which are marked by many very fine, threadlike concentric lines, and the other including *C. astartiformis* Salter, *C. compressa* Ulrich, *C. obliqua* Hall, *C. alta* Hall, *C. recurva* Ulrich, *C. similis* Ulrich, characterized by fewer, stronger concentric lines which are in most cases lines of growth and not surface ornamentation as in the first subgroup.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois, and Glen Park, Missouri.

[1] *Geol. Minnesota,* III, Part II (1894), 580–84.

Superfamily ARCACEA Deshayes
Family CYRTODONTIDAE Ulrich
Genus CYRTODONTA Billings

CYRTODONTA SULCATA sp. nov.

PLATE XXV, FIGURE 18

Shell small, convex, subquadrangular to broadly ovate in outline, dorsal margin behind the beaks straight, slightly longer than high. Beaks small, gibbous, not very prominent, moderately incurved, situated about one-third of the length of the shell from the foremost part of the anterior margin. Umbonal regions full, blending with the general convexity of the shell. Anterior to the umbonal region a broad, shallow sulcus, widest at the ventral margin, becoming narrower and finally dying out about three-fourths of the distance from the ventral margin to the beak. The position of the sulcus is almost at right angles to the hinge line, and therefore diverges ventrally from the more oblique axis of the umbones. Dentition and muscle scars unknown. Greatest length of a typical specimen, 15.4 mm., greatest height, 12 mm.

This species is very similar to *Cyrtodonta obesa* Ulrich in size and proportions, and for this reason, as well as because of the subcentral position of the rather inconspicuous beaks, it has been classed with *Cyrtodonta* and not *Vanuxemia*. The shell of *Crytodonta sulcata* sp. nov. is relatively thin, and not marked by the thickened growth laminations characteristic of *Vanuxemia*. However, none of the known representatives of this species show the position of the anterior adductor muscle scar, so the generic affiliation cannot yet be considered to be established. In comparison with *Cyrtodonta obesa,* this species is not as convex, is less ovate in outline, with the beaks more nearly in the middle, has less oblique umbones, and an anterior sulcus.

Horizon and locality: Kimmswick limestone at Glen Park, Missouri; (?) Batchtown, Illinois.

Superfamily PTERIACEA Dall
Family CONOCARDIIDAE Neumayr
Genus CONOCARDIUM Bronn

CONOCARDIUM LIMATULUM sp. nov.

PLATE XXV, FIGURES 14–17

Shell medium-sized, subtriangular in outline, length about twice the height, posterior wing somewhat longer than anterior. The region of

greatest convexity is from the beak to the base of the shell, body of the shell well elevated above the wings, with curvature more abrupt to the anterior than the posterior wing. The posterior wing is triangular, depressed, with the posterior margin nearly straight, making an angle of about 50° with the cardinal margin. The anterior wing is small, produced into a cylindrical tube at the extremity, rapidly expanding to join the body of the shell. Beaks somewhat anterior to the middle, small, but prominent, and closely incurved over the hinge-line. Umbonal slopes angular, sharply defined, gradually widening to the base with the obliquity somewhat posterior. Cardinal line straight with anterior margins inflected; ventral margins of the wings joining the lower margin of the shell without notches, so that the entire ventral margin is regularly curving.

The posterior wing is covered with 8 fine radiating ribs which are crossed by many fine but sharply defined regularly spaced wavy concentric lines. An area equal to the width of three plications at the margin separates the last plication from the cardinal line, while anteriorly the posterior wing is terminated by a thickening of the shell over a narrow space equal to the width of two plications at the margin. Both anterior and posterior areas bordering the posterior wing are crossed by continuations of the wavy concentric lines which cross the plications.

Posterior to the midrib of the body of the shell 4 simple plications can be counted, which are stronger and more prominent than those on the posterior wing. Between these plications concentric lines can be seen, but they are inconspicuous, never crossing the ridges of the plications, and do not give the shell a cancellated appearance as on the posterior wing. The midrib is elevated above the remainder of the shell, thickened, from which a very finely striated expansion of the shell extends, which increases in width downward from the beaks, until that part which is directly beneath the ventral margin attains to a width equal to that of the entire shell above it. Anterior to this peripheral girdle, 8 simple plications can be counted at the margin, similar to those back of the midrib, but somewhat more crowded and smaller. The central body is then terminated anteriorly by 2 coarse plications which are only weakly marked by concentric lines. All of the plications anterior to the midrib curve forward.

The anterior wing joins the body of the shell in a moderately coarse plication which is of the same type as the two adjacent plications on the central body, but somewhat shorter and narrower than these. The remainder of the anterior wing appears smooth, but with a good lens, extremely fine lines running parallel to the ventral margin can be detected.

MEASUREMENTS OF A PERFECT LEFT VALVE

	Mm.
Length of hinge-line	7.4
Width of umbonal region	4.3
Length of anterior wing	3.6
Length of posterior wing	2.9

Conocardium beecheri Raymond from the Chazy, *C. immaturum* Billings from the Black River limestone at Paquette Rapids on the Ottawa River, and *C. antiquum* (Owen) from the Richmond are the only American species of this genus described from Ordovician localities. *C. limatulum* sp. nov. is somewhat larger than the other known Ordovician forms, and also differs strikingly in the nature of the surface ornamentation. *C. beecheri* Raymond, while being nearly of the same proportions and only a little smaller, differs from *C. limatulum* in having coarse instead of fine plications on the posterior wing, and fine instead of coarse plications on the body of the shell. *C. immaturum* Billings, in addition to being little over half the size, differs from *C. limatulum* sp. nov. in being less sharply carinated at the umbones, in having a notched rather than a smooth juncture of the ventral margin of the wings with the body of the shell, and in having no differentiation in the intensity of the plications. From the very poor original figure of *C. antiquum* (Owen), it is hard to draw any sharp comparison, except that the Richmond form is very small, and does not appear to have the unusual development of striations shown by *C. limatulum* sp. nov.

Conocardium limatulum sp. nov., although larger than other Ordovician species of the same genus, is smaller than most of the later Paleozoic forms. In general proportions, it is somewhat similar to *C. ohioensis* Meek of the Onondaga, but differs from it and all other species of the genus in the peculiarity of the surface ornamentation.

It should be noted that in the description of this species, the writer has not followed the ordinary American usage of orienting the valves so that the abruptly truncate extremity is posterior and the end with gaping margins anterior. It is assumed that the gaping margin indicates the position of the siphons and hence the posterior extremity of the shell. This orientation, while adopted by Neumayr, Zittel, de Koninck, Miller, and others, is not used by Hall, nor Billings and Raymond in the description of the Ordovician species referred to in the foregoing. With the orientation used here, it is seen that *Conocardium* agrees with the majority of other pelecypods in the position of the siphonal area, but differs in having the obliquity of the umbonal region posterior instead of anterior. Besides

those figured, the type series includes two other cotypes W.M. 29053 and 29054.

Horizon and locality: Nine specimens were collected from the Kimmswick limestone in the vicinity of Batchtown, Illinois, and Glen Park, Missouri.

Class GASTROPODA

Subclass STREPTONEURA Spengel

Order ASPIDOBRANCHIA Schweigger

Suborder DOCOGLOSSA Troschel

Family TRYBLIDIIDAE Pilsbry

Genus TRYBLIDIUM Lindström

TRYBLIDIUM RUGOSUM sp. nov.

PLATE XXV, FIGURES 10–11

Shell small, elongate, oval, somewhat wider behind, apex obtusely pointed, above and slightly behind the anterior margin. Shell highly convex transversely, somewhat flattened on top with the sides nearly vertical; longitudinal convexity more gentle, gradually arched from the beak, which is the highest point, to the posterior margin; anterior to the beak the shell falls away abruptly to the front margin in a slightly concave slope. The surface is marked by ten transverse wrinkles between the beak and the posterior margin, weaker and directed a little backward on the lateral slopes, slightly convex backward; continuing with greater strength across the dorsal surface where they are more noticeably convex forward. Where the dorsal surface merges with the steeper lateral surfaces, weak longitudinal wrinkles are developed, which offset slightly the transverse wrinkles on the dorsal surface. Internal characters unknown.

Tryblidium rugosum sp. nov., because of its strong transverse ridges, stands in sharp contrast with other American species of the genus. It is likewise easily distinguished from members of the genus *Archinacella,* because of its pointed anterior end.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri.

Family BUCANIIDAE Ulrich and Scofield

Genus BUCANIA Hall

BUCANIA BATCHTOWNENSIS sp. nov.

PLATE XXV, FIGURES 4–5

Shell of medium height, consisting of three and a half volutions at maturity; volutions depressed, gradually enlarging to the aperture, slopes

slightly concave from the slit band to the sides, which are sharply angular, broadly convex ventrally near the aperture, becoming flatter away from the aperture, subtriangular in cross-section, about twice as wide as high. Umbilicus very large, deep, and steep-sided; aperture subelliptical, somewhat wider than high, lateral angles narrowly rounded; inner lip thicker than outer lip, expanding upward almost to the top of the preceding whorl. Slit-band narrow and elevated. Dorsal surface covered with mediumly coarse parallel revolving ribs or wrinkles, interspersed with finer ribs which may be implanted between the coarser wrinkles, or the result of their bifurcation. The coarser ribs average 7 or 8 in 5 mm. In the umbilicus, the ribs are more oblique and in contrast with the ribs on the back of the volutions which are invariably longitudinal except in very young specimens. These revolving lines are crossed by many weak, lamellose, wavy lines of growth, which are not strong enough in mature specimens to disturb the general longitudinal aspect of the surface markings. These growth lamellae appear to cross the shell nearly at right angles to the slit-band. A large specimen is 25 mm. high; an average specimen measures 15 mm. in height, 12 mm. in width of aperture, and 11 mm. in length of aperture.

In their generic diagnosis of *Bucania,* Ulrich and Scofield[1] restrict Hall's original genus as follows:

> Shell consisting of three to five more or less depressed volutions coiled in one plane, with generally a wide umbilicus and not greatly—never abruptly—expanding aperture. Surface markings consisting of equal or unequal revolving riblets and lines of growth, together producing a more or less cancellated appearance. Revolving lines wavy or wrinkled, oblique, especially in the umbilicus, crossing from the ventral side of a whorl to the dorsal slit-band in the space of about one half a volution. Frequently they are interrupted by strong lamellae, the wavy edges of which are parallel with the lines of growth and the apertural margin. Aperture transverse and somewhat reniform in the typical section, higher and relatively larger in the *B. nashvillensis* section. In the former the lips are thin, the outer one sinuate, and the sinus prolonged into a rather narrow median slit; in the latter the inner lip is rather thick and the slit shorter. Slit-band distinct, raised or depressed. Type, *B. sulcatina* Emmons sp.

Compared with this description, the species described in the foregoing is seen to agree with *Bucania* as restricted, in number of volutions, size and shape of umbilicus and aperture, and general nature of surface markings. Compared with other members of the genus, *Bucania batchtownensis* sp. nov. differs in being more angular at the sides and in having more pronouncedly longitudinal markings on the dorsal surface. In the

[1] *Geol. Minnesota,* III, Part II (1897), 850.

latter characteristic, this species shows some resemblance to *Kokenospira* Bassler, but in all other respects resembles the type of *Bucania*. The surface marking on the umbilicus of mature and on both umbilicus and back of young specimens of *B. batchtownensis* sp. nov. are oblique, and prove this species congeneric with the genus *Bucania* as restricted by Ulrich and Scofield. The closest relative of the Kimmswick species is *B. halli* Ulrich and Scofield, a widespread Black River form, but differs from that species in being more compressed and angular at the sides, and having the longitudinal wrinkles less oblique and the growth lamellae less conspicuous.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois, and Glen Park, Missouri.

BUCANIA PUNCTIFRONS PRIMAEVA var. nov.

PLATE XXV, FIGURES 23–24

Bucania punctifrons (Emmons), a well-marked and widespread species in Trenton formations of New York, Canada, New Jersey, and Tennessee is represented in the Kimmswick limestone by a form which is identical in regard to surface ornamentation, but sufficiently different in other respects to justify the varietal name here given. The surface markings of *B. punctifrons* are unique, so that a very small fragment of a testiferous specimen is sufficient for identification. The surface ornamentation of the typical Trenton form is described by Ulrich and Scofield as follows:[1]

> On each side of the slit and band the whole exposed surface is covered by strong and very sharply defined network, the deep meshes of which are so arranged that they form rows running in two directions, one almost directly across the volutions, the other obliquely forward and outward from the band. Finally, in certain lights, a third arrangement of the meshes will be observed, namely, in a series passing obliquely forward from the sides to the slit-band. The last direction is approximately at right angles to certain more or less distinct lines or varices of growth, which interrupt the regularity of the network on old examples.

Bucania punctifrons primaeva var. nov., while possessing this style of surface sculpture, differs from the Trenton species in being somewhat smaller, with the volutions narrower, more rounded, and considerably less angular at the sides.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois.

[1] *Geol. Minnesota,* III, Part II (1897), 894.

Genus PHRAGMOLITES Conrad

PHRAGMOLITES MULTINOTATUS sp. nov.

PLATE XXV, FIGURE 22

Shell compressed, discoidal, small, from 8 to 13 mm. in diameter; volutions very gradually enlarging, three in number. Whorls higher than wide, attenuated on top, highly carinated; base of keel not sharply set off from the rest of the shell, but joins the lateral slopes in gentle concave curves; volutions widest at the suture, where they become abruptly rounded, thus sharply defining the umbilicus. The subangularity of the ventral surface of the whorls is somewhat variable, but in all observed cases, the umbilicus is very sharply defined. The surface is covered by the zigzag imbrications characteristic of the genus, but in this species the markings are many and crowded, from 4 to 6 in a distance of 2 mm., directed very slightly backward, and diverging a little outward. These imbrications stand out but slightly from the general surface of the whorls, so that the shell is not strikingly roughened. No transverse or longitudinal striations have been observed.

Phragmolites multinotatus sp.nov. stands in marked contrast with almost all the other members of the genus because of its rather small size and the great number of zigzag markings. Compared with *P. dyeri* (Hall), which is similar in size and number of imbrications, the latter is more abruptly carinated, the width of the whorls is relatively greater, while the transverse lamellae of *P. multinotatus* sp. nov. are not so elevated and are never curved backward. This species agrees with *P. compressus* Conrad in having volutions which are higher than wide and which enlarge slowly, but differs in having more of the subimbricating lamellae and in lacking transverse and longitudinal striations. *P. fimbriatus* (Ulrich and Scofield) has more rounded whorls, which are more sharply keeled, and marked by fewer, stronger growth lamellae. *P. triangularis* (Ulrich and Scofield), while agreeing in the abrupt inflection at the umbilicus, differs in that the volutions expand much more rapidly than those of *P. multinotatus* sp. nov.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois, and Glen Park, Missouri.

Suborder RHIPIDOGLOSSA Troschel

Family PLEUROTOMARIIDAE d'Orbigny

Genus LOPHOSPIRA Whitfield

LOPHOSPIRA LINEATA sp. nov.

PLATE XXV, FIGURES 20–21

Shell medium-sized, volutions 4 or 5, apical angle 90° to 95°. Whorls subangular, the last one very wide, subventricose below, tricarinate, the

upper whorls bicarinate in appearance because the lower carina in each case is obscured by the suture; peripheral angle composed of two sharply elevated lines embracing a relatively wide grooved area; lower carina rather thin, separated by a concave space from the peripheral region, well below the elevated keel of the whorl; upper carina sharper and stronger, situated about halfway between the suture and the peripheral angle; slopes from the upper carina biconcave. Aperture wider than high. Surface marked by fine, sharp, subequal lines, which curve backward rather obliquely from the suture to the peripheral band, below which they curve more gently backward to the umbilicus. Across the band, the striations are nearly vertical.

Lophospira lineata sp. nov. is clearly of the *L. bicincta* (Hall) group, but differs in the exceedingly low spire, and corresponding higher apical angle, and wider band, which gives the shell a more linearly ruled appearance. In *L. bicincta,* the shell is nearly vertical between the peripheral band and the lower carina, while in *L. lineata* sp. nov. the surface of the shell falls away rather abruptly between the band and the lower carina. Compared with *L. humilis* Ulrich, this species has a higher apical angle and a considerably wider and somewhat flatter last whorl. *L. lineata* sp. nov. differs from both of these species in the more oblique direction of the surface markings backward from the suture to the peripheral band. The holotype is 9 mm. high and 12 mm. across the last whorl; the peripheral band is 1 mm. wide near the aperture.

Horizon and locality: Kimmswick limestone at Glen Park, Missouri.

Family TROCHONEMATIDAE Zittel

Genus GYRONEMA Ulrich

GYRONEMA INTERMEDIUM sp. nov.

PLATE XXV, FIGURES 2–3

Shell thick, medium sized, wider than high, apical angle about 85°, body whorl constituting the most prominent part of the shell. Volutions not all preserved in the type, but four are indicated and probably five or more are present in the complete organism. The older whorls are relatively small, ventricose, well rounded, enlarging gradually, turning rather abruptly into the body whorl which enlarges very rapidly to the aperture. Sutures well impressed; aperture large, subcircular, peristome complete, inner lip rather thick and almost obscuring the umbilical perforation, which is small. The entire surface is covered with many fine spiral lines every fifth one tending to be slightly strengthened, from 3 to 5 in 2 mm. These revolving lines are crossed by many, very fine lines which are directed slightly backward from the suture to the peripheral region, thence

becoming more vertical on the lower parts of the whorls. Slight growth wrinkles occur on gerontic specimens, but it is not certain that younger shells are so distinguished. The holotype is 23 mm. high from the umbilicus to the middle of the third volution, and 28.5 mm. wide across the body whorl.

This species is singular because of a combination of characters which individually have been taken as generic peculiarities of *Holopea, Trochonema,* and *Cyclonema.* The general shape, close coiling, rapid rate of enlargement of the body volution, deeply impressed sutures, small umbilicus, and large, rounded aperture of *Gyronema intermedium* sp. nov. are common to many species now grouped under Hall's rather poorly understood genus, *Holopea.* On the other hand, this form agrees with *Trochonema* Salter in general style of surface ornamentation and complete peristome, but lacks the deep umbilicus, wide vertical peripheral band, and carinae which give the shells of *Trochonema* a roughened appearance. Compared with *Cyclonema* Hall which has many species whose surface ornamentation approximates that of our species, it is seen that all true *Cyclonemas* have discontinuous peristomes.

The genus *Gyronema* Ulrich, to which this peculiar shell is referred, was made to receive certain forms, in which, according to the author, the whorls are "generally more ventricose than in *Trochonema,* mouth only moderately oblique, umbilicus small, the surface, on the lower half especially, with numerous spiral ridges among which those corresponding with the two which bound the vertical peripheral band in *Trochonema* are sometimes not easily recognized." In this genus have been placed such widely different species as *Gyronema pulchellum* Ulrich and *G. percarinatum* Ulrich, forms which are intermediate between typical *Trochonema* and typical *Cyclonema.* Since the surface markings of the species under discussion forbid grouping it with *Holopea,* and the complete aperture indicates closer relationship with *Trochenema* than *Cyclonema,* while the surface markings and small umbilicus are those of the true *Cyclonema,* it would seem that *Gyronema* is the most convenient receptacle for this clearly transitional form.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri, and (?) Batchtown, Illinois.

Genus HOLOPEA Hall

HOLOPEA MISSOURIENSIS sp. nov.

PLATE XXV, FIGURES 6–9

Shell medium sized, average height 15 mm., width 22 mm. Spire low for the genus, volutions rapidly expanding, ventricose below, higher than

wide, subelliptical in section, four in number. Suture only moderately impressed because of the slight flattening of the dorsal surface of the whorls. Umbilicus rather small but distinct. Aperture large, subelliptical, somewhat oblique, inner lip partly obscuring the umbilical perforation. Surface marked by faint, crowded, irregularly spaced growth lines, which are not crossed by revolving lines of any sort. Mature shells are relatively smooth except for these growth lines, and free from any pronounced vertical wrinkling.

This species is closely related to *Holopea insignis* Ulrich and Scofield, a Black River form which is characterized by its low spire, deeply impressed sutures, and rapidly expanding volutions. *H. missouriensis* sp. nov. differs from this species in having somewhat higher spire, less deeply impressed sutures, irregularly instead of regularly spaced growth lines, and no revolving lines. A specimen collected by Foerste from the top of the Plattin limestone in Ralls County, Missouri, and compared with *H. parvula* Ulrich may be conspecific with *H. missouriensis* sp. nov. Judging from Foerste's figure,[1] his specimen agrees with the Kimmswick species in size, elevation of the spire, and number and rate of enlargement of the whorls.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri; (?)Plattin limestone, Ralls County, Missouri.

Suborder PTEROPODA Cuvier

Family HYOLITHIDAE Nicholson

Genus HYOLITHES Eichwald

HYOLITHES MULTICINCTUS sp. nov.

PLATE XXV, FIGURE 13

Shell conical, elongate, gradually tapering, subtriangular in outline, lateral angle sharply rounded. Ventral side almost flat; dorsal side divided by a sharp, narrow, median ridge, which becomes wider and broader toward the aperture; lateral faces slightly concave. The entire surface is covered with crowded, well-defined, rounded, transverse striations which cross the median ridge at right angles to the axis of the shell, whence they curve backward rather abruptly over the concave areas of the dorsal surface and then gradually turn forward again as they traverse the deflected lateral angles. Indications of very faint, discontinuous, longitudinal striations can be seen on well-preserved specimens with a good lens, but with the naked eye the transverse lines appear to be uninterrupted. About 5 of these lines occur in a length of 1 mm.

[1] *Bull. Sci. Laboratories, Denison Univ.*, XIX, 207, Pl. 21, Fig. 6.

MEASUREMENTS OF THE HOLOTYPE

Apical angle	12°
Length	25.5 mm.
Width at aperture	10 mm.
Width at apical end	5 mm.

The type is broken at the apical end and probably was between 30 and 40 mm. long.

The relationship of this species is with *Hyolithes miseneri* Foerste from the Whitewater member of the Richmond at Richmond, Indiana. Comparing *H. miseneri* Foerste with *H. baconi* Whitfield, a closely related species in Black River formations of Wisconsin, Minnesota, and Missouri, Foerste says:

> The transverse striae are more prominent (in the former). Along the median line of the shell they curve slightly downward; laterally they curve more strongly downward as far as the lateral sides of the shell where they begin to curve rapidly upward. From this it is assumed that on the flattened side of the shell the transverse striae curve strongly upward as in other species of *Hyolithes*. The vertical striae are finer but distinct. An almost identical species occurs in the Kimmswick of southern Missouri.[1]

It is seen from this comparison that the species here described as *Hyolithes multicinctus* sp. nov., and which Foerste regards as "almost identical" with *H. miseneri,* is distinct from *H. baconi* because of the curvature and strength of its striations. Compared with *H. miseneri,* it is apparent on well-preserved specimens of *H. multicinctus* that although closely agreeing in shape of shell, number, and direction of transverse striations, the longitudinal striations are at best only faintly indicated and never as continuous and prominent. In the enlarged figure of *H. miseneri*[2] the surface of the shell is seen to be covered with a network of lines formed by intersection of the transverse and longitudinal striations. Under high magnification, the dorsal surface of well-preserved specimens of *H. multicinctus* sp. nov. shows no such reticulation. The transverse striations are broken here and there, or crossed by extremely fine vertical lines not more than 0.1 mm. long and never continuous.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri.

[1] *Jour. Sci. Lab., Denison Univ.,* XIX (1920), 212.

[2] *Jour. Cincinnati Soc. Nat. Hist.,* Vol. XXII, No. 2, Pl. 1, Fig. 1c.

Genus PTEROTHECA Salter

PTEROTHECA TRIANGULARIS sp. nov.

PLATE XXV, FIGURE 1

Shell triangular in outline, apertural margin gently convex, sides straight or slightly concave, rounded at the lower extremities. Apex terminal incurved, entire shell from front to back gently arcuate. Dorsum abruptly and strongly keeled, carina becoming stronger and expanding to the front margin, which is deeply notched. Sides of dorsum abruptly deflected to the lateral margins, producing a longitudinal convexity between the slightly concave slopes at the base of the carina and depressed lateral margins. Surface covered with fine growth lamellae which are parallel to the apertural margin.

MEASUREMENTS OF HOLOTYPE

	Mm.
Length	30.5
Width at front	40.8
Width in middle	28
Height of carina at front margin	8

Pterotheca triangularis sp. nov. is distinguished from other members of the genus in being more triangular in outline, with the width across the middle relatively less, and in having more abruptly deflected lateral margins. Its closest relative is apparently *P. saffordi* (Hall) found in the Stones River at Lebanon, Tennessee, from which it differs in the more marked triangularity of its outline, the more depressed lateral margins, and the convexity between the carina and the sides.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois, and Glen Park, Missouri.

Suborder CONULARIIDA Miller and Gurley

Family CONULARIIDAE Walcott

Genus CONULARIA Miller

CONULARIA TRENTONENSIS OCCIDENTALIS var. nov.

PLATE XXV, FIGURE 12

Specimens of a *Conularia* have been collected in the Kimmswick limestone of both Missouri and Illinois, which possess the characteristic surface sculpture of *C. trentonensis* Hall and which in the fragmental state cannot be well distinguished from the common New York species. A well-preserved specimen collected by Gerald Knight from the Kimmswick near Imperial, Jefferson County, Missouri, shows that the Kimmswick form

tapers more gradually to the apex, the apical angle being 12° instead of 18°–20° as in *C. trentonensis* Hall and *C. trentonensis var. multicosta* Ruedemann. It is clear that this specimen is not in the least distorted, and the low apical angle seems to be sufficient basis for the separation of this form from the more rapidly expanding Trenton species. The surface markings of *C. trentonensis occidentalis* var. nov. consist of very regularly spaced transverse ridges crested with minute granules closely spaced and crossed by short longitudinal striae. Compared with *C. trentonensis* Hall, which has from 6 to 9 transversé ridges in 5 mm., *C. trentonensis rogersensis* Foerste from the upper Trenton at Rogers Gap, Kentucky, which has 11 striae in 5 mm., and *C. trentonensis multicosta* Ruedemann which has from 15 to 17 ridges in 5 mm., the Kimmswick variety has more widely spaced transverse bars, usually 7, but occasionally 6 in a distance of 5 mm.

Horizon and locality: Kimmswick limestone, Jefferson County, Missouri, and Calhoun County, Illinois.

Phylum ARTHROPODA

Subphylum BRANCHIATA

Class CRUSTACEA

Subclass TRILOBITA Walch

Order HYPOPARIA Beecher

Family HARPEDIDAE Corda

Genus EOHARPES Raymond 1905

The generic term *Harpina* was proposed by Novák in 1884 to characterize those Ordovician trilobites from the Bohemian basin which closely resemble the Silurian and Devonian genus *Harpes* exteriorly, but differ in having the hypostoma roughly oval instead of angularly pentagonal in outline. In 1905 Raymond suggested *Eoharpes* to replace the term *Harpina* which had been preoccupied in 1844 and again in 1870. The family Harpedidae is represented by comparatively few species, and in America neither species nor individuals are anywhere common. Unfortunately, when an isolated specimen has been found, if the hypostoma is not present, it has been put into *Harpes* or *Eoharpes* according to whether it has come from Silurian or Devonian rocks, on one hand, or Ordovician, on the other. It is to be hoped that the Harpedidae of America may be thoroughly revised, but until that has been accomplished the writer would like to suggest certain criteria which may be used as a basis for distinguishing *Harpes* from *Eoharpes*.

The only exterior characteristic that Novák mentions for distinguishing the Bohemian specimens of *Eoharpes* from *Harpes* is the tendency in the former to have fewer thoracic segments. Unfortunately, examples showing the complete thorax are quite as uncommon as hypostomas, and since the cephalon is the part of this rare trilobite usually found, a generic distinction would best be made on some peculiarity of the head.

In speaking of *Eoharpes minnesotensis* and comparing it with the described species of *Harpes,* Clarke[1] says that "the character of the ornamentation, the form of the glabella and its lobation, the absence of broad, lobate expansions about the basal angles of the glabella, the oblique direction of the ocular ridges, as well as the curve of the marginal outline, are all distinctive characters."

The writer has before him several specimens of Devonian *Harpes* from Bohemia as well as a Niagaran form from America, and many illustrations of the European species by Barrande, Schmidt, Richter, and others; likewise specimens and pictures of the Ordovician forms which have been referred to *Eoharpes.* On the whole it would seem that the cephalic margin of *Harpes* is less deeply pitted than that of *Eoharpes.* This is not invariably true, however; nor is there a constant difference in the curve of the marginal outline. The absence of broad, lobate expansions at the base of the glabella of *Eoharpes minnesotensis* and the oblique ocular ridges of that species cannot be taken as generic peculiarities, because *Eoharpes ottawaensis* has lost both lobate expansions about the basal angles of the glabella as well as eye lines which meet the glabella squarely. The most striking difference that seems to be of general application is in the form of the glabella. The glabella of *Harpes* is notably longer, narrower, and more strongly arched than that of *Eoharpes.* In many cases the glabella of the former is not gently convex, but rises to a steep ridge as seen in *H. ungula* and *H. venulosus,* which seems never to be the case in *Eoharpes.*

EOHARPES UNISERIALIS Raymond

PLATE XXVIII, FIGURES 8–10

Eoharpes uniserialis Raymond, *Bull. Mus. Comp. Zoöl.,* LXVII, No. 1 (1925), 15, Pl. 1, Figs. 8–9.

This description is based upon specimens from Batchtown, Illinois, and Glen Park, Missouri, and was written before Dr. Raymond had published his description of the species. Although the genal spines are shorter and less sharply curved than those of the specimens described by Raymond from Mincke, Missouri, there is little doubt that the author's

[1] *Geol. Minnesota,* III, Part II (1894), 755, Fig. 76.

specimens are of the same species. The steep-sided cephalon, the well-defined posterior glabellar lobes, the deep "alar" depressions, and the narrow border are striking characteristics shared by the specimens in both collections.

Cephalon subelliptical in outline; contour anterior to a line produced laterally from the occipital furrow is almost a perfect semicircle. Genal spines slightly longer than the length of the cephalon on its median line, tapering and curving inward very gently. Cephalon strongly convex, falling off on the sides almost perpendicularly to the cephalic border, and on the front not quite so steeply. Glabella prominent, strongly but evenly convex, ending anteriorly in an obtuse, rounded termination. First pair of glabellar furrows lacking, second pair short, just visible to the naked eye, extending inward and slightly backward. The posterior furrows extend inward for about one-third the width of the glabella, and strongly backward, almost reaching the occipital furrow, thus well defining the posterior lobes. Occipital segment elevated, narrow behind the glabella, laterally forming a vertical elevation along the posterior margin of the cephalon, which curves backward, gradually passing into the genal spines at a little less than a right angle to the cephalic border. Occipital furrow shallow, widest on the median portion of the glabella, narrower and deeper behind the posterior glabellar lobes, extending laterally as a shallow marginal furrow onto the cheeks, but terminating where the cheeks are abruptly bent downward. On each side of the base of the glabella, the irregularly semioval space, peculiar to the Harpedidae, in this species is sharply outlined by being abruptly sunk below the general surface of the cheeks. Cheeks strongly convex, highest at the eyes. Eyes small, opposite the middle glabellar furrows and at the distal end of well-defined eye-lines, which extend forward, meeting the glabella at a rather low angle, just a little behind the anterior end. The depressed area of the cheeks is outlined by the broad sigmoid curves of the dorsal furrows which approach the glabella anteriorly, narrowing and deepening between the eyes and the glabella, and meet in front, defining the anterior margin of the glabella.

The cephalic border is narrow for the genus, gently concave with a narrow smooth thickened margin, widest in front, narrowing very gradually to the end of the genal spines. With the exception of the occipital furrow, glabella, and the adjacent depressed areas of the cheeks, which are smooth, the surface is covered with small crowded pits. These openings are generally circular, widest at the surface, and have no definite arrangement. The pits in the border of *Eoharpes uniserialis* are highly char-

acteristic, being more pronounced than those of any other member of the genus.

Pygidium very small, weakly convex, the length about one-third the width. Axial lobe rather prominent, gently convex, width about equal to length, marked by four distinct annulations which are sharply flexed anteriorly in the middle. Axial rings are produced without interruption into ribs which traverse the pleural lobes almost to the margin. Pleural lobes flat but abruptly deflected at the margins.

MEASUREMENTS

	Mm.
Width of cephalon at occipital furrow	17
Length of cephalon along axis	11
Width of brim in front	2.7
Width of brim at junction with genal spine	2
Length of glabella	5.6
Width of glabella across posterior lobes	6
Width of glabella at second furrow	4
Distance between the eyes	8.4
Length of eye lines	2.7
Height of cheeks above brim	4.6
Length of pygidium	2.3
Width of pygidium	6.8

Formation and locality: Kimmswick limestone near Batchtown, Illinois, Mincke and Glen Park, Missouri.

Order OPISTHOPARIA Beecher

Family REMOPLEURIDAE Corda

Genus REMOPLEURIDES Portlock

REMOPLEURIDES MISSOURIENSIS Foerste

PLATE XXX, FIGURES 4–9

Remopleurides missouriensis Foerste, *Bull. Sci. Lab. Denison Univ.*, XIX (1920), 220, Pl. 21, Fig. 17; Pl. 22, Figs. 17*a, b*.

In the original description of this very common Kimmswick trilobite, only the cranidium was described. The writer has good specimens of the eye, complete free cheeks, and hypostomas from several localities, but as yet no pygidium has been discovered which can be referred to the species.

The facial sutures originate on the posterior margins of the cephalon very near the dorsal furrows, at the base of the palpebral lobes, and curve

upward and outward over the tops of the eyes and then inward to the anterior margin of the cranidium. The palpebral lobes rise abruptly to the height of the fixed cheeks and occupy the entire proximal portion of the free cheeks. The upper three quarters of the eyes is occupied by the visual surface. The eyes are long and narrow, extending from near the posterior margin forward, following the curvature of the dorsal furrows, for about two-thirds of the length of the glabella. Eye facets are extremely minute, arranged in vertical rows. The visual surface is defined below by a rather deep rounded furrow, underneath which is a round, slightly projecting platform which forms the base of the palpebral lobe. From the eye lobe, the remainder of the free cheeks, which is flat, is produced into two parallel spines that curve gently downward and backward. These spines are separated by a furrow only, which originates in a round foramen, 0.4 mm. in diameter, and situated near the center of the cheek opposite a point on the eye about one-third its length from the posterior end. The inner of the two spines narrows rapidly to a point, and is about two-thirds the length of the other, which narrows gradually to a more blunt termination. The ventral surface of the spines is convex and longitudinally striated. With the exception of the palpebral lobes, the free cheeks are without ornamentation.

The hypostoma is a quadrate body with two long lobes, lenticular in section and tapering to points, with a deep buccal notch between them. The ventral surface is ornamented with raised longitudinal lines, one of which follows the margin of the entire body and lobes, including the buccal notch. A somewhat stronger line than this extends from the angle of each lobe, passing near the margin of the notch and slightly diverging from it, and becoming obsolete before reaching the muscle scars. A smaller line near the lateral margins extends from the angles of the lobes to points somewhat in front of the muscle scars. Between this line and the lateral margin is a fourth line whose anterior position is similar to the last but which extends only halfway to the end of the lobes. Muscle scars ovate, separated from the buccal notch by a semicircular ridge. The dorsal surface of the hypostoma is weakly convex, upon which the oval muscle scars show conspicuously. The marginal lines are similar to those on the ventral surface, but usually not so well preserved.

Horizon and locality: Kimmswick limestone in Ralls, Pike, and Jefferson counties, Missouri; near Batchtown, Illinois.

Family ASAPHIDAE Burmeister

Subfamily ASAPHINAE Raymond

ISOTELUS GIGAS DeKay

PLATE XXV, FIGURE 25; PLATE XXVI, FIGURES 1–2

Isotelus gigas DeKay, 1824, *Annals Lyceum Nat. Hist. N.Y.*, I, 174, Pl. 12, Fig. 1; Pl. 13, Fig. 1.

ISOTELUS MAXIMUS Locke

PLATE XXV, FIGURE 26

Isotelus maximus Locke 1838, *Second Ann. Rept., Geol. Surv. Ohio,* p. 246, Figs. 8–9.

For the full synonymy of these species see R. S. Bassler, *Bull. 92, U.S.N.M.*

Fragments of these common trilobites are plentiful in the Kimmswick, being represented in the collection by many cranidia, free cheeks, thoracic segments, and pygidia. Neither complete specimens nor complete cephala have been available for study. The largest free cheeks lack genal spines and are referable for this reason to *Isotelus gigas*. Some of the smaller free cheeks have well-developed genal spines which indicate the presence of the *I. maximus* type. No other indication of specific differences among these plentiful asaphid remains could be found. It is probable that the presence or absence of genal spines does not indicate two biologically distinct species. The general smaller size of the specimens bearing the spines and the absence of such on larger examples may mean, as Clarke has suggested, that there is a tendency to shorten and gradually eliminate the spine during the growth period of the animal. Again, these spines may be secondary sexual characteristics, although neither thesis can be conclusively established from the evidence. The constant association and the striking similarity of *I. gigas* and *I. maximus* in many localities points to the separation of the species on the ground of the absence or presence of genal spines as highly artificial.

Two free cheeks from the Kimmswick near Sulphur Springs, Missouri, have been referred provisionally to *Isotelus*. The general outline agrees with that of the free cheeks of *I. gigas* but differs in having a pedunculated eye around which there is a distinct groove. When more is learned about this form, it may be found to be more closely related to *Vogdesia bearsi* Raymond from the Chazy than to *Isotelus gigas*.

Horizon and locality: Kimmswick limestone near Kimmswick, Sulphur Springs, and Glen Park, Missouri; near Batchtown, Illinois.

Genus HOMOTELUS Raymond

HOMOTELUS LAEVIURUS Raymond

PLATE XXVII, FIGURES 8–10

Homotelus Raymond, 1920, *Bull. Mus. Comp. Zoöl.*, LXIV, No. 2, 285–86.
Homotelus laeviurus Raymond, *ibid.*, LXIV, No. 2, 290; LXVII, No. 1, 92, Pl. 4, Figs. 4–5.

In his original description of this species, Dr. Raymond states that *Homotelus laeviurus*

has a short broad cranidium, of little convexity, on which the glabella is entirely merged into the general surface, and dorsal and glabellar furrows are quite absent. The median pustule is small but prominent on the otherwise smooth surface, and the shell seems devoid of puncta. The free cheeks and the thorax are unknown.

The pygidium is evenly convex and the only marking is a very slight swelling indicating the posterior end of the axial lobe. Even in internal casts the outline of the axial lobe shows only vaguely.

Homotelus laeviurus is a common trilobite in the Kimmswick limestone and is always found associated with *Isoteloides kimmswickensis* sp. nov. and *Isotelus gigas* De Kay. The cranidium agrees with that of the former in having a median pustule. This pustule, however, is always smaller in *Homotelus*. The palpebral lobes are always farther forward than those of *Isotelus* and *Isoteloides*, about one-third of the eye being anterior to a transverse line drawn midway between the occipital furrow and the front margin of the shield. The longitudinal convexity of the cranidium readily distinguishes *Homotelus* from *Isotelus* and *Isoteloides* in that the test is deflected rather abruptly downward to meet the anterior margin. While having the isoteliform type of glabella and sutures, *Homotelus laeviurus* is more blunt-headed than its associated relatives.

The pygidium differs from that of *Isotelus gigas* and *I. maximus* in the total or nearly total absence of a depressed border and in being relatively shorter and wider.

Horizon and locality: Kimmswick limestone near Sulphur Springs and Glen Park, Jefferson County, Missouri; Mincke, Missouri; near Batchtown, Illinois.

Genus ISOTELOIDES Raymond

ISOTELOIDES KIMMSWICKENSIS sp. nov.

PLATE XXVII, FIGURES 1–4, 11; CF. 5–7

Although the Kimmswick limestone carries a large representation of asaphids with bifurcated hypostomas, little discriminative examination

has been accorded them. This is undoubtedly due to the fact that these trilobites are clearly of the *Isotelus* type, with cephalon and pygidium smooth and possessing depressed borders. For this reason they have all been referred broadly either to *Isotelus gigas* DeKay or *I. maximus* Locke according to the absence or presence, respectively, of genal spines. In the writer's study of some of this material, several specimens were found which cannot be considered synonymous with either of these two ubiquitous forms. They differ most strikingly in having a defined glabella, a median tubercle, and a narrow, well-defined axial lobe. These characteristics place them without doubt in the genus *Isoteloides* Raymond.

DESCRIPTION

Cephalon moderately convex, semielliptical. In the absence of a specimen with free cheeks attached, it is difficult to know the nature of the genal angles. One free cheek under observation seems to fit the specimens under discussion, and if this is correct, the genal angles are produced into sharp spines. Dorsal furrows broad and shallow, converging slightly between the palpebral lobes as they join the shallow neck furrow, and diverging anteriorly until they meet the shallow anterior marginal furrow. Glabella thereby is weakly outlined, subquadrate, expanding slightly forward. Median tubercle situated midway between the posterior limit of the eyes. Anterior border broadly concave. Glabella about three-fourths the total length of the cephalon.

Thorax unknown.

Pygidium triangular in outline, slightly wider than long. Axial lobe narrow and well defined, with no annulations. The surface more highly convex than that of the cranidium and with a concave border.

MEASUREMENTS

	Millimeters		
Total length of cranidium	22	17	25
Greatest width of cranidium	19	13	21.2
Distance between eyes	13	8.8	14
Length of pygidium			19.5
Width of pygidium			24
Greatest width of axial lobe			7

This species is markedly different from *Isoteloides homalonotoides* (Walcott), the only other member of the genus described from rocks of Black River age thus far. The original description of *I. homalonotoides* is as follows:

Glabella elongate, pointed in front; broadest at the anterior third. The dorsal furrows and occipital furrow give a subquadrate form to the central por-

tion of the glabella similar to that in the species of the genus *Homalonotus*. The occipital segment is defined, back of the glabella, by a slight depression which is more strongly marked behind the eyes. A pair of glabellar furrows are indicated by shallow depressions behind the eyes.

Pygidia associated with specimens of the above glabella have a subtriangular outline, prominent axial lobe, marked convexity, anterior margin with a distinct pleural groove, and a shallow depression between the external margin and the outlined pleural lobes. The subtriangular form and strongly marked axial lobe relate the pygidia to the equally distinct associated glabellae.

A large pygidium referable to this species is three inches in length, by three and one-half in breadth at the anterior margin.

Cotypes of cranidium and pygidium are preserved in the collections of Walker Museum and are pictured for the first time in this paper. The large pygidium mentioned by Walcott is also at hand, and seems to have differences which would exclude it from the species in question, and probably from the genus. This specimen lacks the wide border which characterizes *Isoteloides homalonotoides* and has an axial lobe whose convexity and elevation is less than that of the pleural lobes. *Isoteloides homalonotoides* is conspicuous for an axial lobe which stands up sharply with greater arch and higher elevation than the curve of the adjacent lateral lobes. In that the axial lobe of this specimen is quite broad and not so sharply delineated as the axial lobe of typical members of *Isoteloides,* it is more closely akin to *Isotelus*.

The pygidium collected by Whitfield from the Trenton rocks of Grant County, Wisconsin, first described as *Asaphus triangulatus* and later referred to *Asaphus homalonotoides* Walcott, agrees with the type before the writer. The cranidium found by Raymond from the Black River at Ottawa and referred to *Isoteloides homalonotoides,* on the other hand, does not agree with the type and probably belongs to a species as yet undescribed. In lacking the broad, concave anterior border, the cephalon is relatively shorter, giving quite a different appearance from that of *I. homalonotoides*.

Isoteloides kimmswickensis sp. nov. lacks the long, pointed concave border which is so conspicuous on the cranidium of *I. homalonotoides;* the dorsal furrows of the latter are almost parallel so that the glabella is nearly straight-sided, whereas in the former the glabella is constricted between the palpebral lobes and enlarges a little anteriorly.

Several pygidia from the Kimmswick limestone referred to *Isoteloides kimmswickensis* agree quite closely with the type specimen of *I. homalonotoides*. Despite this close agreement, these pygidia from the Kimmswick limestone cannot be considered synonymous with *I. homalo-*

notoides because all the associated cranidia from the various localities where collections were made agree closely in all respects, one with another, with the new species, *I. kimmswickensis*. Raymond has pointed out the phylogenetic development of *Isoteloides* from *Asaphus* or an Asaphus-like ancestor, through *Megalaspides* Brögger, which shows for the first time a narrow, depressed border on the front of the cephalon. From *Megalaspides* came *Isoteloides,* with its depressed borders on both cephalon and pygidium. By Beekmantown time this evolution had been consummated, as is evidenced by *Isoteloides whitfieldi* Raymond. That this genus persisted until middle Ordovician time with but little tendency toward progressive evolution is shown by the great similarity of pygidia in all known species of *Isoteloides*. Slight variation in the cranidia is of specific value only. While the typical *Isoteloides* persisted almost unchanged through lower and middle Ordovician times, *Isotelus* which undoubtedly sprang from some Isoteloides-like form marks the final result of this evolutionary line, namely, a smooth trilobite.

Horizon and locality: Kimmswick limestone, Glen Park and Sulphur Springs, Jefferson County, Missouri; Batchtown, Illinois.

Family ILLAENIDAE Corda

Genus ILLAENUS Dalman

ILLAENUS DEPRESSICAPITATUS sp. nov.

PLATE XXVIII, FIGURES 11–14

This species presents many points of similarity to *Illaenus americanus* Billings and has generally been referred to that species. Although no complete specimens have yet been found, several detached cranidia and pygidia which seem to belong together have been observed. These show constant peculiar characteristics which differentiate this form from *I. americanus*.

DESCRIPTION

Cranidium large, strongly convex, more strongly arched longitudinally than transversely; two-thirds as long as wide. The glabella is unique in being but gently convex on the sides and flat to broadly concave in the middle. This concavity shows strongly on some of the casts of larger individuals, deeper at the posterior end, and gradually disappearing forward about halfway to the anterior margin. The dorsal furrows are deep, extending about one-third of the whole length of the head; the curve of these furrows is comparable to that of *I. americanus*. Fixed cheeks produced laterally so that the width across the cranidium between the palpebral lobes is relatively greater than the similar dimension in *I. americanus*.

Specimens show considerable variation in the convexity of the anterior region of the head.

Thorax unknown.

Pygidium less convex than the head with the posterior margin broadly and uniformly rounded. Sides abruptly truncated, almost at right angles to the anterior margin and almost parallel to the longitudinal axis of the body. The axial lobe, always less than half the length of the pygidium, is well defined at the anterior margin by the dorsal furrows, which become very shallow around the posterior end. Posterior to the axial lobe, a sharp narrow ridge runs backward almost to the margin of the shell. On specimens showing the doublure, this ridge is represented by a sharp depression. Fine lines radiating from the axial lobe are absent in this form.

This species differs from *Illaenus americanus* chiefly in the depressed region of the glabella, the more strongly truncated sides of the pygidium, the ridge posterior to the axial lobe, and the absence of fissure-like radiating striae on the pygidium.

Although this form agrees with *Illaenus latiaxiatus* Raymond and Narraway in the strong truncation of the lateral lobes of the pygidium, it differs in the depression on the glabella, and by longer, deeper, and more curved dorsal furrows. Likewise, the axial lobe of the pygidium of *I. latiaxiatus* is strikingly long and more prominent, and lacks the ridge which characterizes *I. depressicapitatus* sp. nov.

Formation and locality: Kimmswick limestone near Batchtown, Illinois and Glen Park, Sulphur Springs, and Cape Girardeau, Missouri.

Genus BUMASTUS Murchison

BUMASTUS ROWLEYI Foerste

PLATE XXVIII, FIGURES 15–18

Bumastus rowleyi Foerste, *Bull. Jour. Sci. Lab., Denison Univ.*, XIX (1920), 215, Pl. 21, Figs. 16*a*, *b*; Pl. 22, Figs. 16*a*, *b*.

This form is closely related to *Bumastus indeterminatus* (Walcott). The general shape of both is elongate elliptical, strongly convex. The cranidia of both agree in some important particulars. Both are marked by deep dorsal furrows, which fade out just before reaching the pits in front of the eyes. These pits in both contain a small central tubercle. The cranidia of both are moderately convex except toward the anterior margin, where they curve quite abruptly downward.

Thorax of *B. rowleyi* known only from an imperfect specimen showing ten narrow, flat segments.

Pygidia of both are very convex with concave slopes to the lateral and posterior margin.

B. rowleyi differs from *B. indeterminatus* in having a longer, narrower cranidium, and a less rounded, more subtriangular pygidium. Although no measurements of the parts of *B. indeterminatus* have been recorded, a good idea of the holotype can be obtained from a study of the figure given by Raymond.[1] Measurements of large, medium, and small cranidia, and pygidia of *B. rowleyi* are as follows:

	Millimeters		
Cranidia:			
Length along median line	40	24	14.8
Width between palpebral lobes	48	31	18
Pygidia:			
Greatest length	49	31	10
Greatest width	61	38.5	12.8

In comparing these measurements with the holotype of *Bumastus indeterminatus*, it is evident that the length and width of the cranidium of *B. rowleyi* are more nearly equal than similar dimensions of the former. Likewise, the pygidium of the former is almost circular in outline.

Formation and locality: Kimmswick limestone along Sanders branch in Ralls County, Missouri; Sulphur Springs and Glen Park, Missouri; Batchtown, Illinois.

BUMASTUS BILLINGSI Raymond and Narraway

PLATE XXVIII, FIGURES 1–7

Cf. *Bumastus trentonensis* Emmons, 1842, *Geology New York, Report of Second District*, p. 390, Fig. 1.

Cf. *Illaenus trentonensis* Hall, 1847, *Pal. N.Y.*, I, 230, Pl. 60, Fig. 5.

Bumastus orbicaudatus Clark, 1897, *Pal. Minn.*, III, 722, Fig. 5.

Bumastus holei Foerste, 1920, *Bull. Denison Univ.*, XIX, 214, Pl. 21, Fig. 15; Pl. 22, Fig. 15*c*. Raymond, *Bull. Mus. Comp. Zoöl.*, LXVII, No. 1, 116–17, Pl. 8, Figs. 5–6.

Bumastus billingsi Raymond and Narraway, *Ann. Carnegie Mus.*, IV (1908), 250, Pl. 61, Figs. 1–2. Raymond, *Bull. Victoria Memorial Mus. 1* (1913), p. 34, Pl. 3, Fig. 12.

In his original description of this form, Raymond makes the following comparisons:

This species differs from *Bumastus trentonensis* and *B. milleri* in the following particulars: the size is much greater, the dorsal furrows on the cephalon are stronger, and on the thorax are further apart and fainter, the cephalon is more strongly arched and incurved in front, the lunate scars of the cephalon are further forward and stronger, and the thoracic segments are proportionately wider.

[1] *Bull. Mus. Comp. Zoöl.*, Vol. IX (1916), Pl. 2.

Dr. Raymond believes that *Illaenus trentonensis* (Emmons) should not be taken as the type of that species, because the original specimen is lost and the figure that remains is inadequate to give a clear picture of distinguishing characteristics. Emmons' specimen was found in the Black River or Trenton limestone at Watertown, New York. Clarke, on the basis of priority, superseded *Bumastus milleri* (Billings), which is well described and figured. Raymond disagrees with this and retains the name proposed by Billings for the specimens collected at Ottawa. In the comparison cited in the foregoing, Raymond has taken the forms described by Clarke from the Trenton at Trenton Falls, New York, as the type of *Bumastus trentonensis*.

Since it is now certain that more than one species of Bumastus occur in the Black River and Trenton formations, and since it is improbable that Billings and Emmons described the same form, it seems best to follow Raymond in leaving to *Bumastus trentonensis* the forms described by Clarke. Although No. 1 of Emmons' figures is that of a comparatively large specimen, the exact characteristics cannot be made out from a study of the plaster cast, which is now before the writer. This specimen from a boulder at Hogansburg, New York, is manifestly different from the small trilobite called *Illaenus trentonensis* by Emmons and taken by Clarke as the type of *Bumastus trentonensis*. It seems best to follow Clarke and Raymond in retaining the name *Bumastus trentonensis* for the smaller specimens, and in considering the larger one as a different form.

The trilobites which the writer has referred to *Bumastus billingsi* Raymond and Narraway are all too large to be confused with *B. trentonensis*. On the other hand, the dorsal furrows on the cephalon are not always strongly marked, but since most of the specimens are casts and since some show strong dorsal furrows, the absence of such furrows on some of the specimens can be attributed to the condition of preservation. Even if it should develop that the Kimmswick form has weaker dorsal furrows than the type from Hull, Quebec, the correspondence between the two in all other details is very striking and points to a close relationship.

In the *Paleontology of Minnesota* Clarke pictures a cranidium from the Galena shales at Wykoff, Minnesota, which he referred to *Bumastus orbicaudatus* Billings. This figure closely resembles the common *Bumastus* from the Kimmswick and can likewise be referred to *B. billingsi*. Foerste described this Kimmswick form as *Bumastus holei* and pointed out the probable identity of it with *Bumastus orbicaudatus* Clarke, but he did not mention the close similarity and probable identity with *B. billingsi*.

A. D. Hole, in an unpublished manuscript written in 1910, says that

the largest pygidia of the Kimmswick form "agree rather closely with *B. billingsi* in size and in having on the cast faint transverse annulations and two oval prominences." In speaking of the casts of cranidia which he studied, Hole says,

> These cranidia, while agreeing with *B. billingsi* in being very convex and incurved, differ in having lunate scars that are less sharply defined and situated rather farther back, in the absence of the dorsal furrows, and in the presence of a faint median ridge and furrows. Again the thorax, while agreeing with *B. billingsi* in its very wide middle lobe, faintly marked, and in the number of its segments, has segments which are proportionately much narrower.

In studying a large number of specimens of this form from the Kimmswick, the large, well-defined lunules on the cranidium have been found to be one of the most striking characteristics. It is true that these are missing on some of the poorer examples, but such cases are undoubtedly due to imperfect preservation. Their position on the cephalon is essentially similar to that of the lunules of *B. billingsi.* In the same way, some specimens do not show the dorsal furrows, but all the better-preserved examples do. In the two complete specimens from the Kimmswick, one from near Glen Park, Missouri, and the other from Cape Girardeau, Missouri, the thorax agrees with that of *B. billingsi* in having ten smooth, nearly flat segments, marked by a very wide axial lobe. From the figures given by Raymond and Narraway, the thoracic segments of the Canadian specimens appear somewhat wider than those from the Kimmswick. Until more complete specimens are found from both localities, it cannot be certain that this difference in width is a constant one.

In the specimen from Glen Park, Missouri, the shortening of the pleurae of the anterior thoracic segments can be made out. On the first four segments, the outer ends of the pleurae are truncated much in the manner of the specimen described by Raymond in 1913.

Locality and formation: Trenton at Hull, Quebec, and Kimmswick near Batchtown, Illinois; Sulphur Springs, Glen Park, and Cape Girardeau, Missouri.

Genus THALEOPS Conrad

THALEOPS OVATA Conrad

PLATE XXX, FIGURES 15–16

Thaleops ovata Conrad, *Proc. Acad. Nat. Sci., Philadelphia,* I (1843), 332, Clarke, *Geol. Minn.,* III, Part II (1897), 716, Fig. 25–28; Raymond and Narraway, *Ann. Carnegie Mus.,* IV (1908), 247, Pl. 60, Figs. 11–13; Pl. 61, Figs. 6–7; Slocom, *Field Mus. Nat. Hist.,* Geol. Ser., IV (1913), 56, Pl. 14, Figs. 6–8.

For further references, see R. S. Bassler, *Bull. U.S.N.M. 92.*

This well-known species is represented in the collections of the Walker Museum by one almost complete specimen from the Kimmswick

limestone of Calhoun County, Illinois. Several cranidia of small size referable to this species have been collected from the Kimmswick near Batchtown, Illinois. They are all without free cheeks, but show by their peculiarly extended palpebra that they belong to *Thaleops*. From the characteristics shown, they do not appear to differ from *Thaleops ovata*.

Formation and locality: Black River of Wisconsin, Illinois, Minnesota (Platteville); Ottawa, Ontario; Maquoketa at Clermont, Iowa; Kimmswick limestone at Batchtown, Illinois.

Family GOLDIIDAE Raymond

Genus GOLDIUS de Koninck

GOLDIUS SLOCOMI sp. nov.

PLATE XXIX, FIGURES 30–32

Cranidium flat to gently convex, over twice as wide as long. Dorsal furrows deep posteriorly, gradually converging anteriorly to about half the distance to the front margin of the shield, then widely diverging and meeting the shallow furrow which limits the glabella in front, in a rather sharply acute angle. This gives the antero-lateral corners of the glabella a subangular instead of a well-rounded outline. Glabella almost flat on top, descending rather abruptly to the occipital furrow and very gently to the anterior margin of the cephalon. Three faint depressions along the lateral margins of the glabella indicate the vestigial first, second, and third glabellar furrows. The front margin of the cephalon is flat, narrow anteriorly to the glabella but broadening laterally. The occipital furrow is rather wide and deep in the middle, but dies out laterally before reaching the more prominent dorsal furrows. The fixed cheeks terminate anteriorly in a ridge which runs nearly parallel to the front margin of the head and joins the dorsal furrow almost at right angles. The surface of the test is finely granulose, marked with the tracery of fine subconcentric and reticulating lines characteristic of the genus.[1]

The associated pygidia are semielliptical, gently convex, slightly depressed near the margin. The axial lobe is short, subtriangular in outline, limited on the sides by broad, deep, axial furrows, which die out posteriorly. At the point where the axial furrows disappear, the axial lobe is but slightly elevated, constricted, and continues to the posterior margin as a flattened simple rib with gradually diverging sides. In some specimens this median rib is marked by a barely perceptible median furrow. The pleural lobes carry six pairs of ribs. The surface is covered with fine trans-

[1] Barrande, *Syst. Sil. du centre de la Bohême*, Vol. I (1852), Pl. 46, Fig. 23.

verse lines which are interrupted by the furrows between the ribs and are convex anteriorly.

MEASUREMENTS

	Mm.
Length of glabella	11.5
Width of glabella anteriorly	15
Width of glabella posteriorly	6.7
Distance of eye from posterior margin of cephalon	2.4
Length of pygidium	29
Width of pygidium	40
Length of axial lobe	8
Width of axial lobe	9.5

Goldius lunatus (Billings), described in 1854 and said to be not uncommon in the middle Trenton at Ottawa, is the only species of Goldius recognized up to this time from the American Ordovician. The presence of only six pairs of pleural ribs in the pygidium, instead of the customary seven or eight found in the more highly developed representatives of the genus in younger formations, is suggestive of the phyloneanic condition of this Trenton form. *Goldius laticauda* (Wahlenberg) from the middle Ordovician of Sweden and *G. hibernicus* (Portlock) from the Caradoc-Bala beds of Ireland are species likewise in the adolescent stage of development, as shown by the presence of but six pairs of pleural ribs. There has not been much discriminative study of trilobites of this type from American localities, and consequently *Goldius lunatus* (Billings) has been made to receive all Trenton representatives of the genus. Specimens have been reported from Birch Island, Kimvow Bay, Winnipeg,[1] and described from Albany, New York,[2] and Jacksonburg, New Jersey.[3]

Goldius slocomi sp. nov. is clearly distinct from the specimen described by Billings and later figured by Logan[4] in having a glabella with subangular rather than well-rounded antero-lateral corners. In this respect *Goldius slocomi* is quite similar to *G. laticauda* (Wahl.) as figured by Fr. Schmidt.[5] The pygidium of *G. slocomi* differs from that of Billings' specimen in having a simple postaxial rib. The division of the postaxial rib, however, depends on the development of the specimen and, as Clarke

[1] Whiteaves, *Pal. Foss., Geol. Surv. Canada,* III, Part III (1897), 233.

[2] Ruedemann, *Bull. New York State Mus.,* XLIX, 65, Pl. 4, Figs. 10–11.

[3] Weller, *Geol. Surv. New Jersey, Pal.,* III (1903), 198, Pl. 15, Figs. 14–16.

[4] *Geol. Surv. Canada, Rep. Progr. for 1853–1856* (1857), p. 338; *Geol. Canada, Geol. Surv. Canada* (1863), p. 188, Fig. 187.

[5] *Rev. Ostbalt. Sil. Trilob.* (1894), Part IV, Pl. 3, Fig. 9.

has commented, may be variable within a species, and therefore of no taxonomic importance.

The specimen figured by Ruedemann and referred to *Goldius lunatus* (Billings) is probably more closely related to the Ottawa species than to *G. slocomi,* because of its well-rounded glabella. It would seem, however, from the figures, that the cranidium from the Rysedorph Hill locality is not identical with Billings' type.

It seems that the peculiar phyloneantic stage of development in *Goldius* represented by trilobites with six pairs of pleural ribs on the pygidium is restricted to rocks of middle Ordovician age. Such forms vary some with the locality, but on the whole are closely related. *Goldius slocomi* sp. nov. in the form of its glabella appears to be closer to the European than to the American forms.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois; Glen Park and Cape Girardeau, Missouri.

HYPOSTOMA gen. ind.

PLATE XXIX, FIGURE 33

A rather large hypostoma was collected from the Kimmswick limestone near Batchtown, Illinois, which resembles no other hypostoma in our collections, and cannot be placed definitely with any known species. It is subquadrate in outline, slightly wider in front, broadly rounded behind. The central body is gently and evenly convex, joining the anterior margin directly, separated by a broad, deep furrow from the postero-lateral margins, which narrow and are bent outward at the antero-lateral angles. The postero-lateral margin is flat, broad, and continues with an even width around the hypostoma. The anterior margin is without a furrow and in outline is slightly convex forward. Length, 7.5 mm.; width across anterior margin, 10 mm. This hypostoma may belong with *Goldius slocomi* sp. nov.

Family PROETIDAE Corda

Genus PROËTUS Steininger, 1831

The genotype *Proëtus cuvieri* Steininger is a Devonian form from the Eifel region, which with other forms had been included in *Calymene*. The original description of the genus is meager, no figure is given, and the only diagnostic characteristics mentioned are that the trilobite has ten thoracic segments and simple eyes. Most of the species subsequently described under this genus have ten thoracic segments, while none can be proved to have simple eyes. It is quite certain that *P. cuvieri* had faceted eyes, since

related forms associated with it possess the compound type of eye, but it is probable that the facets were indistinct in the original specimen.

Much variation can be seen in the cephalons of the many species put into this genus. In *Proëtus batillus* Whidborne from the Devonian of southern England, *P. brevimarginatus* Weller from the Trenton of New Jersey, as well as several other species from Europe and America, the glabella is separated from the border only by a deep furrow. Another type of border is that of *P. subfrontalis* Whidborne from the Devonian of Lummaton, England. Of this species Whidborne says that the glabella is "separated from the border by a wide tumid area defined by two distinct grooves, the innermost of which is continued as a deep groove to form the sides of the glabella." This style of double-furrowed border occurs in many species and with much variation. In *P. latifrons* M'Coy, it is exceedingly wide with the area between the two furrows only weakly convex. In *P. ramisulcatus* Nieszkowski from Stage F_2 in the Bohemian basin, the border is relatively narrow and the area between the two furrows is almost flat. In still a third type, no roll occurs between the glabella and anterior margin of the border, as shown in *P. crassimarginatus* Hall from the Devonian of New York.

Perhaps the first type of border described is the most common throughout the very wide range and distribution of this species. The many species assigned to *Proëtus* in which the glabella is separated by more or less of a roll from the anterior margin, may be found to represent one or more quite distinct genera. With these variations in style of border are variations in size and position of the eye, which may be of more than specific importance.

At the present time, it is not advisable to do more than suggest the possibility of restricting the genus *Proëtus,* because it is understood that a revision of the genus is being undertaken by Dr. Richter, who has access to the large collections from European localities. It is to be hoped that the results of these investigations will soon be published. In the present paper, the name *Proëtus* will be used broadly and will include all Proëtidae which lack isolated basal lobes in the glabella, as well as a strongly elevated ridge around the glabella outside the dorsal furrows. The related genus *Cyphaspis,* which is otherwise similar to *Proëtus,* has a glabella possessing prominent isolated lobes as well as a strongly convex ridge around the dorsal furrow. The genus *Haploconus* Raymond is associated with *Proëtus* and *Cyphaspis* in the Kimmswick limestone and resembles *Cyphaspis* except that it lacks basal lobes on the glabella.

PROËTUS CANALIS sp. nov.

PLATE XXIX, FIGURE 28

Glabella subovate, strongly elevated, rounded in front, truncate behind; lateral furrows nearly obsolete, but their presence is commonly indicated on the larger specimens. The first anterior pair consists of two short furrows which are directed inward and only slightly obliquely backward. The second anterior pair, like the first, lie in front of the palpebral lobe, but unlike the first are somewhat longer and stronger, and run more sharply backward. The posterior pair are less conspicuous than the others and are never marked by a depression. They rise a little forward of the middle of the eye lobe and curve sharply backward to join the occipital furrow at almost a right angle. Occipital furrow sharply impressed; occipital segment never as highly elevated as the glabella, bearing a small tubercle at its median point. Dorsal furrows well defined but shallow. In front the cranidium has a weakly convex, broad roll which separates the glabella from the rather wide, upturned anterior margin.

Although this species is rather common in the Kimmswick limestone, it is only imperfectly known from the cranidium. No free cheeks have been found which could be referred to the cranidia under discussion.

MEASUREMENTS

	Millimeters		
Length of glabella	2.2	2.9	2.9
Width of glabella	2.5	3.2	3.1
Length of cranidium	5	5	5
Width of cranidium	4	4.1	4

Proëtus canalis sp. nov. is very similar to a species described as *P. latimarginatus* by Weller in 1903 from the Trenton limestone of New Jersey. Since Hall used this name in 1888 for a *Proëtus* in the Helderberg at Pendleton, Indiana, the writer proposes the name *Proëtus macrocephalus* for the form described by Weller. *P. canalis* sp. nov. agrees with *P. macrocephalus* in general proportions, but the former is always smaller. Both show a median tubercle on the occipital segment, but *P. canalis* always shows a broad convex roll between the glabella and anterior margin, while this area, although wide, is concave in *P. macrocephalus*. *P. canalis* differs from *P. parvinculus* Hall in possessing a median tubercle on the neck segment and in having visible lateral furrows on the glabella.

A single pygidium collected near Batchtown, Illinois, probably belongs with this species. It is small, subelliptical in outline, with a large,

highly elevated axial lobe showing six poorly defined rings. The axial lobe narrows a little posteriorly and comes to a rather abrupt termination before meeting the flat posterior margin. The pleural lobes are gently and evenly convex and are marked by several poorly preserved ribs, which are stronger anteriorly and appear compound near the front margin. The pygidium is surrounded by a flat narrow margin, which is not crossed by the ribs posteriorly. Because of the poor preservation of this specimen as an internal cast, there is considerable doubt as to the number, direction and strength of the annulations.

Horizon and locality: Kimmswick limestone at Glen Park and Sulphur Springs, Missouri, Batchtown, Illinois.

Genus CYPHASPIS Burmeister

CYPHASPIS GLOBOSUS sp. nov.

PLATE XXIX, FIGURE 27

Entire cranidium subquadrate. Glabella globular, highly convex, standing out conspicuously behind, sloping and enlarging slightly forward. Basal lobes small, almost obsolete, separated from the median lobe by pronounced furrows. A deep furrow surrounds and accentuates the convexity of the glabella. Between the marginal furrow and the dorsal furrow is a convex roll which surrounds the glabella on both sides and in front, and terminates in the occipital furrow. Occipital furrow deep, not quite as broad as the occipital segment. Entire surface seems weakly granulose.

MEASUREMENTS

	Mm.
Length of glabella	1.7
Width of glabella	1.3
Length of cranidium	2.4
Width of cranidium	2.5

This species differs from *Cyphaspis trentonensis* Weller in being smaller, in the greater elevation and convexity of the glabella, and in lacking tubercles. It agrees with *Cyphaspis planifrons* Eichw.[1] from Russia in the abrupt and almost overhanging descent of the glabella into the occipital furrow. It differs from this species in an entire absence of tubercles.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois and Glen Park, Missouri.

[1] Fr. Schmidt, *Rev. Ostbalt. Sil. Tril.*, Part IV, p. 58.

Genus HAPLOCONUS Raymond

HAPLOCONUS TUMIDUS sp. nov.

PLATE XXIX, FIGURES 23, 29

Glabella subovate, highly convex, rounded anteriorly, truncate posteriorly, lateral furrows obsolete, separated from the fixed cheeks by a deep dorsal furrow which completely surrounds it. Cheeks tumid, forming a continuous convex ridge around the glabella and terminating abruptly at the occipital furrow on both sides. This ridge is widest at the occipital terminals and narrows down gradually to about half of its greatest width just anterior to the glabella. In young specimens this ridge turns quite sharply round the glabella, with corners almost rectangular, and runs in almost a straight line across the front of the cephalon. In more mature specimens, the ridge becomes more gently curving, with the outer margin almost semicircular. A sharp furrow separates the front of this roll from the anterior margin of the cranidium, which is drawn forward to a point, as in the Asaphids. Occipital furrow deep and narrow, running across the entire cranidium; neck segment narrow. Surface covered with small, rounded pustules, irregularly arranged.

MEASUREMENTS

	Millimeters	
Length of glabella	1.8	2.2
Width of glabella	1.4	2
Length of cranidium	2.8	3.8
Width of cranidium	3.2	4.1

The genus *Haploconus* was proposed by Raymond to include trilobites very similar to *Cyphaspis,* but differing in not having isolated basal lobes on the glabella and in having a less prominent axial lobe on the pygidium. Three species have been described, all of Ordovician age. *Haploconus tumidus* sp. nov. differs from the genotype, *H. smithi* (Billings), in having a more convex glabella lacking indications of furrows, and in having a pustulose surface. It differs from *H. galenensis* (Clarke) in having a more tumid glabella and roll, and an undoubtedly pustulose test. These peculiarities likewise distinguish it from *H. brevimarginatus* (Walcott).

Horizon and locality: Glen Park, Missouri; and Batchtown, Illinois.

Family LICHADIDAE Corda

Genus ACROLICHAS Foerste

ACROLICHAS CUCULLUS (Meek and Worthen)

PLATE XXIX, FIGURES 1–9

Lichas cucullus Meek and Worthen, *Proc. Acad. Nat. Sci., Philadelphia* (1865), p. 266; *Geol. Surv. Illinois,* III (1868), 299.

Lichas (Platymetopus) cucullus Clarke, *Geol. Minnesota,* III (1894), 146, Figs. 66–67. Whiteaves, *Pal. Foss., Geol. Surv. Canada,* III, Part III (1897), 236.

Acrolichas cucullus Foerste, *Am. Jour. Sci.,* XLIX (1920), 29, Pl. 1, Fig. 1, *a–g.*

The genus *Acrolichas* proposed by Foerste, with *Lichas cucullus* Meek and Worthen as the genotype, differs from *Amphilichas* Raymond in the following particulars:

The cranidia of both genera are practically identical, both having complete tricomposite lobation, and both lacking occipital lobes. Foerste takes this similarity as an illustration of parallelism of structures in different genera. In commenting upon the dissimilarity of the pygidia, he says:

> In the pygidia of typical *Amphilichas* the axial lobe does not narrow posteriorly to a point terminating at the notch between the free tips of the posterior pair of ribs, as in *Acrolichas.* In the pygidium associated by Schmidt with the genotype of *Amphilichas* the axial lobe narrows posteriorly for about half the length of the pygidium and then widens again; moreover, the posterior pair of lateral ribs bear a diagonal furrow, a feature unknown in *Acrolichas.*

Acrolichas cucullus is one of the most common trilobites in the Kimmswick limestone of Illinois and Missouri, and is easily distinguished from associated lichads because of the slight concavity of the median lobe of the glabella on its posterior slope, which gives it a peculiar subconical protuberance, even in young specimens.

Pygidia constantly associated with the species possess an axial lobe which narrows to a point posteriorly. This point just reaches the notch separating the two posterior ribs. The three pairs of lateral ribs all have free tips, the first two having diagonal furrows, the last pair being without a furrow. Several specimens of pygidia in the collection show no deviation from the pointed axial lobe, nor from the character of the surface markings, and constant association with the cranidia of *Acrolichas cucullus* make it quite certain that this species as limited by Foerste is not variable in its major characteristics.

Horizon and locality: Black River at Janesville, Wisconsin; Lake Winnipeg, Canada; Kimmswick limestone, Alexander and Calhoun counties, Illinois; Glen Park and Sulphur Springs, Missouri; Prosser at Wykoff, Minnesota.

ACROLICHAS ASPRATILIS sp. nov.

PLATE XXIX, FIGURES 11–15

Glabella broadly convex in front, flat along the posterior slope. Median lobe flat and almost parallel sided from the occipital furrow forward halfway to the anterior margin; widening anteriorly and rather sharply bent downward in front. Lateral lobes subquadrangular, somewhat wider in front, with the lateral slopes even; a little less than half of the anterior surface bent forward. Glabellar furrows narrow but quite deep, communicating directly with the occipital furrow. Palpebral lobes relatively small, situated but a short distance in front of the occipital furrow. Occipital furrow broader and deeper than the glabellar furrows. Occipital segment flat on top, wider in the middle than on the ends, bowed forward toward the median lobe of the glabella, very gently convex from end to end. The entire surface is roughened by many tubercles and spine bases of various sizes arranged with no definite order on the test.

MEASUREMENTS OF CRANIDIA

		Millimeters	
Length	13.6	18.6	29.0
Width between palpebra	15.0	19.0	...
Length of median lobe	12.8	16.8	24.6
Width of median lobe at occipital furrow	4.8	6.0	10.4

The largest of these cranidia was figured by Foerste[1] and compared with *Acrolichas conifrons* Ruedemann, but from the study of material recently collected, the Kimmswick species is now known to be quite distinct from *A. conifrons*. Foerste has shown that the point where the median lobe descends into the frontal margin is less angular in the Kimmswick specimens than in *A. conifrons*, and this is true of the cranidia collected by the writer. Furthermore *A. aspratilis* sp. nov. is only gently convex across the posterior slope of the glabella from one lateral lobe to the other, some specimens being almost flat. The glabellar furrows divide the lateral from the median lobes in such a way that the outline of convexity forms an even curve, and does not rise to three apexes of convexity over each lobe as in *A. conifrons*.

The pygidia associated with these cranidia are of such a nature as to cast some doubt upon the generic relationship of this species with *Acrolichas*. Three pygidia have been under observation, two of which were collected in the same beds as those which contain examples of the cranidium here described. These pygidia do not fit conveniently into either *Amphilichas* Raymond or *Acrolichas* Foerste but appear to combine im-

[1] *Am. Jour. Sci.*, XLIX (1920), 45, Pl. 2, Fig. 5, *a*, *b*.

portant characteristics of both, together with having one of the important characteristics of *Hoplolichas* Dames. On the other hand, the surface of the test is covered with spine bases similar to those of *Acrolichas aspratilis* sp. nov.; because of this and the intimate association geologically, and the absence of any other associated lichad pygidium other than that of *Acrolichas cucullus,* which is large enough to belong to *A. aspratilis,* there is strong evidence that the peculiar pygidia in question belong with this species. One of these pygidia, a specimen from the Kimmswick at Cape Girardeau, Missouri (U.C. 10771), was figured by Foerste (loc. cit.) as *Hoplolichas (?) welleri.* This name was not used in the text and no formal description was given. Foerste was of the opinion that this pygidium represented an aberrant form of *Acrolichas cucullus* (Meek and Worthen), with which it is associated. It seems clear now that its relationship is closer to *Acrolichas* than to *Hoplolichas* chiefly because no *Hoplolichas* cranidia have been found either at Cape Girardeau, Missouri, or anywhere else in the Kimmswick limestone.

The genus *Amphilichas* Raymond was founded upon the species *Lichas laevis* Eichw. One single fragmentary pygidium was described and figured by Fr. Schmidt[1] in his exposition of this species, and it is rather doubtful whether this pygidium really belongs with the cranidia of *Amphilichas laevis.* Although fragmentary, it is clear from the figure that the pygidium in question bears diagonal furrows on the third pair of lateral lobes and an axis which does not come to a point posteriorly. If this can be taken as the type of *Amphilichas,* then the pygidia here referred to *Acrolichas aspratilis* sp. nov. agree in regard to the axial lobe, but disagree in having the third pair of lateral lobes devoid of diagonal furrows. On the other hand, the pygidia of *Acrolichas,* as Foerste so clearly pointed out from the genotype *Acrolichas cucullus,* have an axial lobe which narrows posteriorly to a point terminating at the notch between the free tips of the posterior pair of ribs, all of which bear diagonal furrows. The pygidia in question agree in all these particulars except that the axial lobe does not narrow to a point posteriorly, but after narrowing rapidly, it expands at one-third or less of the length of the pygidium from its posterior end.

These pygidia agree with *Hopolichas tricuspidata* Beyrich only in the fact that in both the axial lobe fails to come to a point, a character shared by other lichad genera. The pygidium of *H. tricuspidata* is not known to have posterior ribs ending in free tips, has dorsal furrows which curve backward from the axial lobe about one-third of the distance from the

[1] *Mem. l'Acad. Imp. Sci. St. Petersbourg,* XXXIII (1885), 49, Pl. 6, Fig. 10.

posterior margin, and is marked by a wide depression all around the outer margin.

Since the pygidia from the Kimmswick have free tips at the ends of all of the ribs, and the posterior pair of ribs is not marked by diagonal furrows, and since the furrow limiting the posterior margin of the second axial ring does not persist on either side to the dorsal furrows, this peculiar form has been placed in *Acrolichas* rather than in a new genus in order not to add to a nomenclature already overburdened. It is believed that these pygidia belong with *Acrolichas aspratilis* sp. nov. regardless of the variation in the axial lobe of the pygidium.

Horizon and locality: Kimmswick limestone at Glen Park, Sulphur Springs, and Cape Girardeau, Missouri; near Batchtown, Illinois.

ACROLICHAS SUBDISJUNCTUS sp. nov.

PLATE XXIX, FIGURES 25–26

Several cranidia, all small or medium sized, are found in the Kimmswick limestone, associated with *Acrolichas cucullus* (Meek and Worthen) and *A. aspratilis* sp. nov. They differ from these species chiefly in that the glabellar furrows, shortly before reaching the occipital furrow, change abruptly from sharp, deep grooves to shallow poorly defined depressions. The surface of the test is quite similar to that of *A. cucullus*, being marked with tubercles but no spine bases, and from the small size it might be inferred that this form represents the young stages in the development of *A. cucullus*. Equally small specimens of *A. cucullus* have been collected, however, and readily identified by the characteristic protuberance of the middle lobe of the glabella anteriorly and the slightly concave form of this lobe posteriorly. None of these small examples of *A. cucullus* have the peculiarly arrested glabellar furrows of *A. subdisjunctus*.

MEASUREMENTS

		Millimeters	
Length of cranidium	12.0	11.2	3.7
Width of cranidium	12.7	12.0	4.0
Length of median lobe	10.7	10.2	3.0
Width of median lobe at occipital furrow	2.0	1.8	1.0

Acrolichas subdisjunctus sp. nov. differs from all other Ordovician Acrolichads in the interruption of the glabellar furrows just anterior to their junction with the occipital furrow. In general proportions it is quite similar to *Acrolichas trentonensis* (Conrad), but differs from that species not only in the interruption of the glabellar furrows but also in having two small notches on the inner margin of the lateral lobes. These notches are

not preserved on all specimens, but when they occur, they are situated about one-fourth and one-half the distance, respectively, from the occipital furrow to the anterior margin. Such indentations occur in other species of lichads and are taken by Reed to indicate the composite nature of the lateral glabellar lobes.

No pygidia have been found which are referable to this species. It is to be expected that the pygidium of *Acrolichas subdisjunctus* sp. nov. approximates closely that of the general *Acrolichas* type as seen in *A. cucullus* (Meek and Worthen), *A. cornutus* (Clarke), *A. champlainensis* (Whitfield), and *Acrolichas hibernicus* (Portlock), and it is possible that some of the smaller pygidia referred to *A. cucullus* really belong to *A. subdisjunctus*.

Horizon and locality: Kimmswick limestone at Glen Park, Sulphur Springs, and Cape Girardeau, Missouri; near Batchtown, Illinois.

ACROLICHAS ANTIQUARIUS sp. nov.

PLATE XXIX, FIGURE 16

Glabella subtrapezoidal in outline about one and one-third times as broad as long, strongly deflected in front. Lobation completely tricomposite. The first pair of glabellar furrows outlining the median lobe are wide and deep, converging rapidly posteriorly but again diverging just before joining the occipital furrow. The lateral lobes, which are taken to be composed of the fused second, third, and fourth lateral lobes of a less modified progenitor, show distinct vestiges of this lobation. What were once the third pair of lateral furrows are represented in this species by a line originating about one-third the way from the occipital furrow to the anterior margin of the fused lateral lobes, and running from the first glabellar furrow diagonally upward and almost completely across both of the lateral lobes. These lines are clearly the persistence of a primitive character and mark off the position of the true fourth glabellar lobe. About one-third of the distance from the anterior margin of the lateral lobes a clearly defined but shallow notch marks the position of the former second glabellar furrows. In this way the ancestral divisions of the lateral lobes are clearly indicated on the glabella. The neck furrow is deep, curving forward behind the median lobe where it is widest, and narrowing down to a very sharp line behind the lateral lobes. The occipital segment is rounded, weakly convex, narrowing laterally, crossing the cranidium in a straight line. The fixed cheeks, glabellar and occipital furrows are smooth; the rest of the cranidium is covered with small tubercles.

MEASUREMENTS OF THE HOLOTYPE

	Mm.
Length of cranidium	8.8
Width of cranidium	10.2
Length of median lobe	7.4
Width of median lobe at occipital furrow	3.2

Reed has pointed out the presence of vestigial characters on such European species as *Oncholichas ornatus* (Angelin), *O. gotlandicus* (Angelin), *Homolichas pahleni* (Schmidt), and others. *Acrolichas subdisjunctus* sp. nov. often shows notches which mark the junction of the second and third with the first glabellar furrows, but *A. antiquarius* sp. nov. seems to be the only specimen of an American lichad of the tricomposite type showing the vestigial third glabellar furrow in entirety.

Acrolichas antiquarius sp. nov. is known from a single well-preserved cranidium and may represent merely an aberrant form of *A. subdisjunctus* sp. nov., which it resembles more closely than any other associated lichad. It differs, however, from *A. subdisjunctus* in having deeper and wider glabellar furrows, which are deepest and widest at their junction with the occipital furrow; a deeper and wider occipital furrow; and a neck segment whose posterior margin is almost a straight line. It agrees with this species in general proportions and in convexity.

Horizon and locality: Kimmswick limestone at Glen Park, Missouri.

Genus HEMIARGES Gurich 1901[1]

This genus was founded upon *Lichas wesenbergensis* Schmidt, a trilobite from Stage E of the Russian Ordovician. *Hemiarges* is well-represented numerically in the fauna of the Kimmswick limestone but, due to a close similarity with *Corydocephalus* Corda, has been confounded with that genus. Reed[2] has pointed out that *Hemiarges* differs from *Corydocephalus* in having small and indistinctly defined occipital lobes, axial furrows which become obsolete posteriorly, an absence of a raised border on the pygidium and the presence of bidentate terminations of the third pleural lobes. The true *Corydocephalus* has a glabella with well-circumscribed central lobe, complete fourth lateral and occipital lobes, as well as complete axial furrows. Two species of *Hemiarges* have been described thus far from American Ordovician localities, *Hemiarges wesenbergensis paulianus* (Clarke), from the Trenton at St. Paul and Wykoff, Minnesota,

[1] Gürich, *Neues Jahrb. f. Miner. Geol., Beil.*, XIV (1901), 526.

[2] *Geol. Mag.*, LXX, No. 712, 456.

and *H. tuberculatus* (Weller), from the Trenton of New Jersey, both of which are listed by Bassler under *Corydocephalus*.[1]

HEMIARGES BARTONI Raymond

PLATE XXIX, FIGURES 17–21; AND 24

Hemiarges bartoni Raymond, *Bull. Mus. Comp. Zoöl.*, LXVII, No. 1 (1925), 128–29, Pl. 8, Fig. 10.

Cephalon subsemicircular in outline, highly convex, with the greatest convexity somewhat nearer the anterior than the posterior margin. The anterior and lateral slopes of the greatly arched glabella are the most abrupt. Median lobe very convex both laterally and longitudinally, rising above the rest of the cranidium; sharply bent downward and widest at the front, extending beyond the lateral lobes. The first glabellar furrows are deep, slowly converging, and constricting the median lobe posteriorly, becoming obsolete in a deep depression at the base of the lateral lobes before meeting the occipital furrow. The well-circumscribed lateral lobes which stand out with a subglobular convexity are formed from the fusion of the second and third glabellar lobes. Second glabellar furrows completely obsolete. Third glabellar furrows shallow, but of sufficient prominence to separate the lateral lobes from the fourth glabellar lobes. The fourth glabellar lobes are poorly defined laterally; dorsal furrows strong anteriorly, but becoming fainter posteriorly. Occipital lobes small, indistinct, merging anteriorly with the fourth glabellar lobes. Fixed cheeks convex, small, and inconspicuous, standing at a much lower level than the remainder of the cranidium. Occipital furrow rather strong, straight, greatly arched medially. Anterior margin of the cephalon separated from the glabella by a narrow concave marginal border. The entire surface with the exception of the furrows is covered with rather large spine bases, which are largest and most numerous on the median lobe.

MEASUREMENTS

	Millimeters	
Length of cranidium	6.0	6.6
Width of cranidium	9.7	10.0
Length of glabella	5.2	6.0
Width of glabella	7.2	8.0
Width at front of median lobe	5.0	4.0
Width at back of median lobe	2.0	1.8

The pygidia associated with this form are short, transversely semielliptical in outline. The axial lobe has three distinct annulations, is con-

[1] *U.S.N.M., Bull. 92*, I, 281.

vex, higher than the rest of the shield, being about one-third of the greatest width of the pygidium at the anterior margin. The sides of the axial lobe are almost parallel, converging slightly in back, where the lobe becomes broadly rounded and terminates in a long narrow postaxial ridge, which does not project over the posterior margin of the shield, and is confluent with the shell of the third pleural lobes. The first two pairs of pleurae bear furrows and extend freely beyond the margin; the third pair are broad, without furrows, each lobe terminating in two short marginal spines. Average specimen 3.2 mm. long and 5 mm. wide. The pygidia in question are of the generalized *Hemiarges* type and might reasonably belong to either *Hemiarges bartoni* Raymond or *H. leviculus* sp. nov., but because of their agreement in size with the cranidia of *H. bartoni* they have been referred to that species.

Hemiarges bartoni is closely related to *H. wesenbergensis paulianus* (Clarke) and *H. tuberculatus* (Weller), as well as to the genotype *H. wesenbergensis* (Schmidt). It differs from the last in lacking the angular projections of the shield anterior to the lateral lobes. It differs from *H. wesenbergensis paulianus* (Clarke) in the greater convexity and bulbous aspect of median and side lobes, and in having a narrower occipital ring. It lacks the flattened dorsal surface, the broad occipital segment, and the angular outline of the head of *H. tuberculatus* (Weller).

Horizon and locality: Kimmswick limestone near Glen Park and Mincke, Missouri, and Batchtown, Illinois.

HEMIARGES LEVICULUS sp. nov.

PLATE XXIX, FIGURE 22

Cephalon subelliptical in outline, weakly and evenly convex, about four-fifths as long as wide. The anterior and lateral slopes of the glabella are somewhat steeper than the posterior slope. Median lobe slightly more elevated than the lateral lobes, evenly convex from front to back. The first glabellar furrows are narrow but sharp, converging very little posteriorly, thus making the median lobe almost parallel sided, becoming obsolete at the base of the lateral lobes. The lateral lobes are well circumscribed on the inside and in front and slope laterally to the margin of the shield. Second glabellar furrows obsolete; third glabellar furrows shallow, poorly defining the fourth glabellar lobes. Occipital lobes very small, showing as a slight intumescence on the bases of the fourth glabellar lobes. Occipital furrow straight, deep, wider than the glabellar furrows. Anterior margin of the shield is flattened and extends well around the lateral lobes before being intercepted by the facial suture. Fixed cheeks poorly preserved, but

probably small and non-protruding. Surface pustulose. Known only from the cranidium.

MEASUREMENTS

	Millimeters	
Length of cranidium	4.2	3.0
Width between outer margins of lateral lobes . . .	5.3	3.8

Hemiarges leviculus sp. nov. differs from *H. wesenbergensis* (Schmidt) in the glabella which is wider than long, while that of the genotype is equidimensional. It differs from *H. wesenbergensis paulianus* (Clarke) in the lesser and more even convexity of the cephalon. *H. leviculus* sp. nov. is always smaller than the associated *H. bartoni* Raymond. It can be distinguished from young specimens of the latter by the lesser convexity, less prominent lateral lobes, narrower glabellar furrows, and its more nearly parallel-sided glabella.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri, and Batchtown, Illinois.

Order PROPARIA Beecher

Family ENCRINURIDAE Angelin

Genus ENCRINURUS Emmerich

ENCRINURUS TRENTONENSIS Walcott

PLATE XXIX, FIGURES 34–35

Encrinurus trentonensis Walcott, *31st Rep. New York State Mus. Nat. Hist.* (1880, adv. sheets, 1877), p. 68. Weller, *Geol. Surv. New Jersey, Pal.*, III (1903), 202, Pl. 15, Figs. 26–27. Grabau and Shimer, *N.A. Index Fossils*, II (1910), 314.

A few fragmentary pygidia of young individuals of this species occur in our collections from the Kimmswick limestone near Batchtown, Illinois. The general outline is triangular, the length equaling the width. The axial lobe is narrow, rounded, and tapers posteriorly; one specimen shows twenty axial rings, with median nodes on the third, sixth, tenth, fourteenth, and eighteenth segment. The pleurae curve sharply to the lateral margins and are marked by nine ribs on each side. An average specimen is 4 mm. long.

Some variation in the arrangement of the tuberculated axial segments has been noticed in this species. The specimens from the Kimmswick seem to agree in this regard more with the Wisconsin specimens described by Walcott, than with the New Jersey example of Weller. The important character, however, is as Weller has stated, the intermittence rather than the exact location of the segments bearing tubercles.

Horizon and locality: Black River at Clifton, Wisconsin, and two

miles north of East Dubuque, Illinois, Kimmswick limestone near Batchtown, Illinois; Trenton at Jacksonburg, New Jersey.

Family CALYMENIDAE Milne Edwards

Genus CALYMENE Brogniart

CALYMENE SENARIA Conrad

PLATE XXIX, FIGURES 40–41

Calymene senaria Conrad, *5th Ann. Rep. Geol. Surv. New York* (1841), pp. 38, 49; Hall, *Pal. N.Y.*, I, 238, Pl. 64, Figs. 3, *a–n*. Weller, *Geol. Surv. New Jersey, Pal.*, III (1903), 203, Pl. 15, Fig. 23. Ruedemann, *Bull. New York State Mus.*, XLIX (1901), 67.

See Bassler, *Bull. 92, U.S.N.M.*, for full synonymy.

Several imperfect cranidia together with many well-preserved pygidia of this species have been collected from the Kimmswick limestone. The genal angles appear to be blunt or well rounded, the anterior part of the cephalon is produced into a long shovel-shaped expansion, and the pleurae of the pygidia are grooved. Although Hall has referred specimens to this species which lack the pronounced anterior lip, the common Trenton form has this lip and should be separated from *Calymene callicephala* Green, which is likewise Trenton but also Lorraine in age, on this basis and on the presence of the grooved pleurae of the pygidium of *C. senaria*. The specimens from the Kimmswick have been studied in comparison with specimens of the common form from Trenton Falls, and were found to agree in the details stated.

Horizon and locality: Trenton of New York, Ohio, Minnesota, etc.; Kimmswick limestone near Glen Park, Missouri; and Batchtown, Illinois.

Family CHEIRURIDAE Salter

Subfamily CHEIRURINAE Raymond

Genus CERAURUS Green

CERAURUS PLEUREXANTHEMUS Green

PLATE XXX, FIGURE 43

Ceraurus pleurexanthemus Green, *Monthly Amer. Jour. Geol.*, I (1832), 560, Pl. 4, Fig. 10; *Mon. Tril. N.A.* (1832), p. 84, Fig. 10, cast 33. Hall, *Pal. New York*, I (1847), 242, Pl. 65, Figs. 1, *a–c*, 1, *e–g* (not 1*d*, *h*, *i*, *m*, or Pl. 66, Figs. 1, *a–g*); Clarke, *Geol. Minnesota*, III, Part 2 (1894), 734, 738. Weller, *Geol. Surv. New Jersey, Pal.*, III (1903), 204, Pl. 15, Fig. 28. Raymond and Barton, *Bull. Mus. Comp. Zoöl.*, LIV (1913), 528, Pl. 1, Fig. 1; Pl. 2, Figs. 1, 2, 7.

See Bassler, *Bull. 92, U.S.N.M.*, for full bibliography.

This species is represented in the Kimmswick limestone by a few glabellas from Batchtown, Illinois. On the basis of the careful study made

by Raymond and Barton, *Ceraurus pleurexanthemus* Green must be limited to ceraurids with very convex glabellas whose forward expansion averages about 1 mm. in 7. The isolated posterior glabellar lobes are small and nearly square. The common ceraurid in the Kimmswick limestone, which is described in this paper as *C. globulobatus* sp. nov. shows a close relationship to *C. pleurexanthemus* as thus limited, but is distinct from that species because of the more rapid divergence of the dorsal furrows anteriorly and the globular posterior glabellar lobes. Associated with *C. globulobatus* at two horizons in the Kimmswick near Batchtown, Illinois, a few detached cranidia have been collected which show the square posterior lobes and the slowly expanding glabella of *C. pleurexanthemus*. The presence of this ubiquitous Trenton type in the Kimmswick emphasizes the close genetic relationship with *C. globulobatus*, which a study of the morphology of the two species suggests.

Horizon and locality: Black River and Trenton at Trenton Falls, New York; New Jersey; Ohio; Tennessee; Minnesota; Canada; Illinois, etc.

CERAURUS GLOBULOBATUS sp. nov.

PLATE XXX, FIGURES 33–36, 38–42

Cephalon, with genal spines, crescentic, transversely convex; axial lobe about one-fourth the total width. Dorsal furrows well marked, sharp at the bottom, diverging anteriorly until opposite the first glabellar furrows, whence they turn abruptly outward to the margin. The angle made by the turning of the dorsal furrows is about 100° and is marked by a deep pit in which a tubercle can be seen in specimens lacking the original shell. Glabella quite highly convex transversely, less so longitudinally, expanding forward rather noticeably. The front of the glabella is broadly rounded, almost straight in some specimens. The first and second pairs of lateral furrows are broad, rounded, and nearly straight, directed slightly backward. The third pair of furrows is stronger, and in turning abruptly back to join the occipital furrow they isolate small posterior lobes, which are characteristically round or nearly so in outline. The occipital furrow is broad and well impressed, extending entirely across the glabella. Occipital segment broad, elevated, and straight. The fixed cheeks are rather highly convex at the eyes but become slightly concave posteriorly; marked by a deep posterior marginal furrow. The genal angles are produced backward and outward into somewhat slender, curved, sharp-pointed spines. Eyes small, situated high on cheeks. The surface of the cephalon with the exception of the furrows and genal spines is covered with coarse

scattered tubercles, and pits of various sizes. Two rows of coarse, anteriorly diverging tubercles can be discerned on some glabellas.

Pygidium small and short. Axial region poorly defined but indicated by a convexity anteriorly which becomes flat posteriorly. Pygidium composed of four nested segments, the first pair of which ends in very long curved, flaring spines. The other three rings increase in curvature posteriorly, the last being almost semicircular. All are convex forward, and a deep depression separates each pair of ribs. The part of the pygidium between the great spines has an undulate outline due to the slight projection of the second and third segments beyond the margin. Surface finely granulose with a few scattered tubercles.

Hypostoma subovate in outline, well rounded posteriorly, flattened anteriorly; greatest width along the anterior margin. Body subtriangular in outline, more strongly convex transversely than longitudinally. Central body separated from the anterior margin by a furrow whose outline is convex forward; it is bounded laterally by a regularly curved furrow which is continuous around the posterior point. Anterior lateral corners produced into auriculate appendages. Body surface pitted; grooves and margins smooth to finely granulose.

MEASUREMENTS

Cranidia:		Millimeters	
Length of cephalon	12.4	11.0	7.8
Width of cephalon	29.6	28.8	18.6
Front width of glabella	9.0	7.6	5.7
Rear width of glabella	6.6	6.3	4.3
Length of glabella	9.6	8.0	5.6
Pygidia:			
Length		6.3	3.5
Width across second segment		5.0	3.8
Length of great spines		6.0	5.0
Hypostomas:			
Length		5.8	7.0
Width (greatest)		7.0	9.0

Ceraurus globulobatus sp. nov. closely resembles *C. pleurexanthemus* Green, which is a common trilobite in almost all exposures of Black River and Trenton rocks, but differs from that species as limited by Raymond and Barton[1] in the following particulars:

1. The glabella shows considerably more expansion anteriorly.

[1] *Bull. Mus. Comp. Zoöl.*, V, No. 2, 528–33, Pl. 1, Fig. 1; Pl. 2, Figs. 1–2.

2. The glabellar furrows are proportionately broader, and the third pair more completely isolate the posterior lobes, which tend to be round rather than square in outline.

3. Axial lobe nearer one-fourth than one-third of the total width.

A variation in the relative width of the glabella at top and bottom can be noticed in some specimens, such as the one whose measurements are given second in the list. This variant approaches *C. pleurexanthemus* in the outline of the glabella, but differs in having the globular posterior lobes and the short, broad glabellar furrows characteristic of *C. globulobatus* sp. nov. From *C. dentatus* Raymond and Barton, this species differs in its much smaller size and rounder and smaller glabellar lobes, but agrees closely in the characters of the hypostoma. It lacks the short, hornlike pair of spines which is typical of the glabella of *C. bispinosus* Raymond and Barton. From *C. miseneri* Foerste, it can be distinguished because of its well-developed genal spines, but this Richmond form approaches *C. globulobatus* sp. nov. in the rate of forward expansion of the glabella.

Horizon and locality: Kimmswick limestone near Glen Park and Sulphur Springs, Missouri; near Batchtown, Illinois.

CERAURUS sp. ind.

PLATE XXX, FIGURE 44

The presence of a large ceraurid which is distinctly unlike any known Trenton form is indicated by a few fragments of the test of the glabella collected in the Kimmswick limestone south of Batchtown, Illinois. The shell is covered with great rounded pustules, as much as 2 mm. in diameter. The glabella is 15 mm. long, almost parallel sided, and shows the first and second glabellar furrows to be very deep, directed inward and backward parallel to each other. The second lobe is thereby rectangular and sharply set off from the rest of the glabella. The character of the surface and the depth and direction of the lateral furrows puts this form in sharp contrast with *Ceraurus pleurexanthemus* Green and *C. globulobatus* sp. nov., with which it is found associated.

Genus CERAURINUS Barton

CERAURINUS PLATYCANTHUS sp. nov.

PLATE XXX, FIGURES 29–32, 37

Glabella subquadrate in outline, almost parallel sided, four-fifths as wide as long, the frontal lobe occupying three-sevenths of the length, the three posterior lobes being smaller and of about equal size. Glabella gently convex transversely and longitudinally. Dorsal furrows clearly defined, sharp at the bottom, converging slightly at front and back. A low,

narrow ridge marks the middle of the glabella from the neck furrow to its point of disappearance near the center of the anterior lobe. The first pair of glabellar furrows are sharply incised, straight, broad, round-bottomed, extending somewhat backward, and becoming narrower and shallower until obsolete, about one-third of the distance across the glabella. The second pair of glabellar furrows are parallel and similar to the first, but do not extend quite so far into the glabella. The posterior glabellar furrows are deeper and extend somewhat farther into the glabella and are bent back at a slightly greater angle than the others. At their inner ends the posterior furrows are connected with the occipital furrow by a shallow curving furrow. The occipital furrow is deep and wide in the axial portion, becoming more constricted laterally where it bends backward to meet the dorsal furrows. The fixed cheeks are large and are marked posteriorly by sharply impressed marginal furrows, which join the dorsal furrows almost at right angles and are separated from the posterior margin by ridges which increase in width toward their outer ends. The genal angles are produced into flat, rather broad, sharp spines, about half as long as the glabella. The palpebral lobe is situated opposite the second glabellar furrow, nearly semicircular in outline, marked at the center by a deep pit from which a short, shallow furrow extends posteriorly. Surface of the cast of the glabella smooth with the exception of the median ridge and a few small pustules on the front of the first lobe. The surface of the fixed cheeks is marked by small pits near the dorsal furrows, and scattered pustules elsewhere.

A hypostoma which is quite distinct from the common ceraurid hypostoma found in the Kimmswick limestone, referred in this paper to *C. globulobatus* sp. nov., was found at the same locality as that of the cephalon described in the foregoing and probably belongs in the same species. In general form it is subovate, broadly rounded posteriorly. Its anterior margin is broadly convex forward, marked laterally by a groove with auriculate projections. Behind this projection the margins widen abruptly into lateral margins which continue in a broad curve around the posterior end. Lateral furrows separate the margin from the central body, which is ovoid in outline and marked posteriorly by two small furrows which originate in the lateral furrows and extend inward and backward a short distance.

Near this hypostoma a well-preserved thoracic segment was found, which may also be referred to this species. Its dorsal furrows are deeply impressed, and the distal parts are bent down almost at right angles to

the proximal. The axial region projects prominently forward and is marked by a deep rounded groove.

MEASUREMENTS OF TYPES

	Mm.
Width of cephalon with spines	43.6
Length of cephalon	16.0
Width of glabella at neck furrow	10.6
Length of genal spine	7.4
Length of hypostoma	10.0
Greatest width of hypostoma	9.4
Width of pleural segment	25.0
Width of deflected end of pleural segment	6.5

This species is closely related to *Ceraurinus polydorus* (Billings) from the Chazy of Newfoundland but differs from it in having straight rather than curved glabellar furrows, flat genal spines, and pitted fixed cheeks. Three American species of Trenton age have been assigned by Barton to *Ceraurinus, C. confluens* Barton, *C. scofieldi* (Clarke) and *C. trentonensis* Barton. From the first *C. platycanthus* sp. nov. differs most strikingly in the strong juncture of the glabellar with the dorsal furrows; from the second in the more slightly backward bending of the posterior furrows; from the third in the absence of the anterior expansion of the glabella and in the lack of curving glabellar furrows. The flat broad genal spines of this species are distinctive and it finds its closest relative, perhaps, in *Ceraurinus spinulosus* (Nieszkowski) from the Baltic provinces.[1]

Horizon and locality: Kimmswick limestone near Batchtown, Illinois.

CERAURINUS TENUISCULPTUS sp. nov.

PLATE XXX, FIGURE 14

Cephalon semicircular, gently convex, bounded by a narrow marginal border. Glabella elongate, subrectangular, enlarging a little anteriorly, front margin broadly rounded. Between the proximal ends of the lateral furrows the glabella is slightly arched above the more gentle convexity of the transverse section; longitudinally the glabella slopes more steeply to the anterior than to the posterior margin. The first and second glabellar furrows are finely but sharply incised, bending backward in even, parallel curves. The third pair of glabellar furrows are wider and deeper and directed backward at a greater angle than the others. From their inner ends, shallow furrows which become wider posteriorly connect the third glabellar furrows with the neck furrow. The occipital furrow is deep

[1] Fr. Schmidt, *Rev. Ostbalt. Sil. Tril.*, Part I (1881), p. 147, Pl. 7, Figs. 6–17.

and sharp, with the central portion parallel to the posterior margin of the occipital segment, and the ends bent slightly backward. The neck segment is rounded on top and has a straight posterior margin. The anterior lobe of the glabella is long, almost half the length of the entire glabella. The cheeks are medium sized, roughly triangular; posterior margin inclined somewhat forward, marked by a deep groove which diverges a little laterally from the posterior margin and meets the lateral marginal furrow almost at right angles. The genal angles bear medium-sized, depressed convex spines. The eye is situated about equal distances from the dorsal and posterior marginal furrows. The entire surface of the cheeks within the marginal furrows is covered with medium-sized punctae irregularly arranged; remainder of the cephalon smooth.

MEASUREMENTS

	Millimeters	
Width of cephalon		22.8
Length of cephalon	11.4	8.5
Length of glabella	9.0	6.7
Width of glabella at occipital furrow	6.4	4.8
Width of glabella at first furrow	8.0	5.6

This species differs from *Ceraurinus scofieldi* (Clarke), a closely related type, in its more elongate glabella, its more clearly incised first and second glabellar furrows, and in its anteriorly expanding glabella. It agrees with *C. trentonensis* Barton in this last characteristic, but differs in having the posterior glabellar furrows more sharply deflected posteriorly and more deeply incised, and in having the eye situated lower on the cheek.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois.

Genus PSEUDOSPHAEREXOCHUS Schmidt

PSEUDOSPHAEREXOCHUS SUBCIRCULARIS sp. nov.

PLATE XXX, FIGURES 17–18

Cephalon wide, glabella very large, evenly convex, subcircular in outline anterior to the straight posterior margin. The glabella is wide and marked by three pairs of glabellar furrows. The first pair are short and nearly straight, starting well forward on the glabella and extending inward and backward at an angle of about 45° with the axis. The second pair are longer, more curving; the third pair are the longest, extending nearly to the summit of the glabella whence they turn backward and join the occipital furrow by a very shallow depression. All glabellar furrows are equal-

ly incised and of similar width. The neck furrow is somewhat deeper, straight, extending well across. The occipital segment is narrow, arched on top, standing well below the convex surface of the glabella. The fixed cheeks are small, separated from the glabella by sharp, narrow, dorsal furrows. The facial suture runs very close to the glabella anteriorly, but a little above the place where the third glabellar furrows join the dorsal furrows it swings away from the glabella almost at right angles and describes a sigmoid curve as it progresses to the lateral margin of the fixed cheek. The eyes are very small and situated at the point where the facial sutures abruptly turn away from the glabella. The entire cephalon is bounded by a narrow convex border which may be produced into spines at the genal angles. The surface of the cheeks is abundantly pitted; that of the glabella is smooth, with the exception of a few small scattered pustules.

MEASUREMENTS

	Millimeters	
Length of glabella	8.0	7.0
Width of glabella at first furrow	5.5	4.5
Width of glabella at third furrow	9.6	7.6

The affinity of *Pseudosphaerexochus subcircularis* sp. nov. is with *P. vulcanus* (Billings) of the Chazy. It agrees with that form in the general proportions of the cephalon, in the wide, subcircular, evenly convex glabella, but differs in having nearly straight first glabellar furrows, and evenly curved second and third glabellar furrows. The second and third pairs of glabellar furrows of *P. vulcanus* describe sigmoid curves, which puts the otherwise similar glabella of *P. subcircularis* sp. nov. in sharp contrast. *P. trentonensis* Clarke from Trenton Falls, New York, has similarly curved glabellar furrows, but the last pair do not reach the occipital furrow as in this species. Furthermore, *P. trentonensis* appears to be a much larger form and lacks the wide subcircular glabella of *P. subcircularis* sp. nov.

Horizon and locality: Kimmswick limestone at Glen Park, Missouri, and near Batchtown, Illinois.

Genus HOLIA nov.

This genus is proposed to include trilobites similar to *Pseudosphaerexochus* and *Nieszkowskia* in having small fixed cheeks and eyes very near the large glabella, but different in having deeply incised glabellar furrows, lateral margins of the glabella tapering forward and truncated sharply by the anterior glabellar margin, basal lobes not isolated, and general convexity slight. The occipital furrow stands in sharp contrast to

that of all other members of the Cheirurinae in being sharply bent forward at each end, extending from the axial region to the dorsal furrows parallel to the third glabellar furrows.

Genotype: *Holia magnaspina* sp. nov.

This genus is named in honor of A. D. Hole, of Earlham College, Richmond, Indiana.

HOLIA MAGNASPINA sp. nov.

PLATE XXX, FIGURES 11–13

Glabella a distorted hexagon in outline, with the sides forming the lateral margins much elongated. Front margin almost straight, not quite as long as the lateral margins. Glabella gently convex on top, sharply bent down at the edges, meeting the general surface of the shell nearly at right angles. There are three pairs of glabellar furrows which are well impressed and are directed backward. All of these are separated from the dorsal furrows by a slight thickening at the margins. The first pair are short, well impressed, originating at the angle made by the junction of the lateral margins with the anterior margin of the glabella, and directed backward at an angle of 60° with the axis. The second pair are longer, almost parallel to the first pair, and somewhat more incised. The third pair of glabellar furrows are very deeply impressed, growing deeper and wider toward their inner ends; they are slightly curved and directed backward to make a sharper angle with the axis than the first two pairs. Between the inner ends of the glabellar furrows is an arched region which expands a little forward, and has a width equal to about one-third of the maximum width of the glabella. The lateral lobes formed by the glabellar furrows are subrectangular, increasing in length posteriorly. The occipital furrow is deep, wide, and parallel to the posterior glabellar furrows laterally; posterior to the median lobe of the glabella the occipital furrow abruptly assumes a normal transverse course, becoming narrower and shallower as it traverses the arched axial region of the cephalon. The occipital ring is convex, narrowing to the middle, posterior margin almost parallel to the occipital furrow. Posteriorly the occipital segment is produced into a broad, nearly flat, mucronate spine, which is about as long as the glabella. Very shallow transverse furrows cross the occipital segment at each side of the elevated axial region, thus forming indistinctly defined occipital lobes, whose outside limits are well marked by the dorsal furrows. The dorsal furrows clearly separate the glabella from the lower surface of the cheeks.

In front of the glabella is a rather wide border whose anterior margin is straight. From this margin the facial sutures diverge somewhat pos-

teriorly as far as the second pair of lateral lobes whence they become parallel to the axis of the glabella, continuing until just above the junction of the occipital furrow with the dorsal furrows. Here they are very near the glabella before they turn almost at right angles to meet the lateral margins of the cephalon. In each of the two angles formed by the facial sutures and the anterior margin of the cephalon is a small, clearly defined depression. The posterior lateral portions of the fixed cheeks are narrow and marked in the middle by a marginal groove.

MEASUREMENTS

		Millimeters	
Length of cephalon without spine	8.9	5.8	3.9
Length of glabella	8.1	5.2	3.4
Width of glabella at occipital furrow	9.1	6.4	4.6
Width of glabella across frontal margin	5.5	3.7	2.4
Length of spine	7.6		

The specific name of this species was first used in an unpublished manuscript written in 1910 by Professor A. D. Hole.

Horizon and locality: Kimmswick limestone near Glen Park, Missouri; near Batchtown, Illinois.

Genus HELIOMERA Raymond

HELIOMERA RAYMONDI sp. nov.

PLATE XXX, FIGURE 3

Known from a very small glabella, elliptical in general outline, gently convex both longitudinally and transversely, but with margins abruptly deflected. Anteriorly the glabella is separated from the narrow, rather thickly rounded marginal border. The glabella is marked by three pairs of glabellar furrows, each bent backward on its inner end to join the furrow posterior to it. The posterior pair extend in a direction nearly perpendicular to the axis, joining with the deeply incised occipital furrow, which extends entirely across, straight in the middle, deflected at the ends. The first pair of glabellar furrows cut the anterior margin at an angle of about 50° with the axis, the second at about 80°, and the third pair are nearly parallel to the occipital furrow, thus forming narrow, club-shaped glabellar lobes. The inner ends of each pair of furrows are so deflected as to be nearly parallel with the axis, thus isolating a central lobe which is about one-third the width of the glabella, parallel sided posteriorly, but expanding forward slightly in front of the inner ends of the first pair of glabellar

furrows. This median lobe is arched posteriorly into a slight conical protuberance, and marked on the anterior margin by a shallow median furrow. The occipital segment is lenticular in outline, rounded, with a strong median pustule. The surface of the test is not preserved in the holotype, but from the cast appears to have been granulose and perhaps finely pustulose. The glabella is 1.5 mm. long and 2.2 mm. wide.

Because of the absence of cheeks in our specimen, little can be added to the knowledge of the affinities of this genus. Raymond has shown that the form of the cephalon of *Heliomera sol* (Billings) is close to *Pseudosphaerexochus,* but the variation in the direction of an isolated central lobe and long isolated glabellar lobes with deeply incised glabellar furrows is not known in that group. The deeply impressed glabellar furrows and the median depression on the frontal lobe suggest *Pliomera* Angelin. The central lobe resembles that of *Acrolichas* and *Amphilichas*. The median pustule on the neck segment of the Kimmswick form is more characteristic of certain opisthoparian trilobites than of any proparian.

Heliomera raymondi differs from *H. sol* (Billings), from the Chazy, the only other known species of this genus, in having an elliptical rather than a semicircular glabella, in the posterior protuberance of the central lobe, and in the presence of a strong median tubercle on the occipital segment.

Horizon and locality: Kimmswick limestone near Batchtown, Illinois.

PYGIDIUM sp. ind.

PLATE XXX, FIGURE 10

A small pygidium was collected about one mile and a quarter southwest of Batchtown, Illinois, from the Kimmswick limestone just above the disconformity which separates that formation from the underlying Plattin. This pygidium probably belongs to the Cheirurinae, but cannot be placed, at the present status of our knowledge, with any known Kimmswick form. Four clearly marked segments are shown; the axial lobe is wide anteriorly, narrowing posteriorly, and marked by a longitudinal ridge which crosses the three sharp annulations, and then divides the fourth segment into two spinelike terminations. The ribs on the pleurae are simple at both ends but bifid in the middle; laterally they extend slightly over the margin as short spines. The axial lobe is well marked by dorsal furrows, and the whole pygidium is moderately convex with abrupt slopes to the postero-lateral margins. Surface finely pustulose. Length, 2 mm.; width 3.4 mm.

Subfamily DEIPHONINAE Raymond

Genus SPHAEROCORYPHE Angelin

SPHAEROCORYPHE ARACHNIFORMIS sp. nov.

PLATE XXX, FIGURES 1–2

Cephalon semielliptical in outline, moderately convex, genal angles produced into rather long, flattened spines, which curve well backward. Dorsal furrows deep except opposite the lateral glabellar furrows, where they become shallow; subparallel until just before reaching the anterior marginal furrow, where they begin to diverge slightly. Wide, shallow, marginal furrows separate the fixed cheeks from the border which is very narrow, thin, and slightly inflexed anterior to the glabella, but wider and thicker on the lateral margins; posteriorly the border is narrow at the dorsal furrows but widens gradually to the genal angles.

The glabella is very prominent, anterior lobe inflated to form an oblate spheroid with its transverse diameter the longest, comprising about three-fourths the entire length. The anterior lobe is encircled by a pair of wide, shallow furrows whose anterior margin is defined by an angular ridge. Laterally these furrows join the dorsal furrows. Near the junction of the occipital and dorsal furrows are situated a pair of triangular lobes which are formed by the widening and deepening of the posterior glabellar furrows until they join the occipital furrow. Occipital segment arched well forward, its posterior margin elevated, surface sloping abruptly into the occipital furrow, which is shallow, not defined anteriorly except behind the posterior glabellar lobes.

The fixed cheeks are large for the genus, convex, sloping abruptly to the dorsal furrows, more gently to the posterior and lateral margins. The facial sutures originate well forward on the lateral margins, extending inward and slightly backward in a sigmoid curve to the base of the palpebral lobes which they traverse, and thence forward to the anterior margin just outside of the dorsal furrows. The free cheeks are triangular, less than one-quarter the size of the fixed cheeks. Eyes prominent, globular, pointed forward, situated opposite the anterior border of the posterior glabellar lobes. Indistinct ocular ridges extend from near the anterior margin of the glabella to the eyes.

The surface of the glabella is smooth except for a few scattered tubercles on the posterior portion of the anterior lobe; the cheeks are finely and closely pitted within the marginal furrows, and smooth on the borders.

MEASUREMENTS

	Millimeters	
Length of cephalon (without anterior lobe)	3.5	3.2
Width of cephalon (without spines)	7.4	6.5
Length of glabella	5.3	4.0
Length of anterior lobe	3.5	3.2
Width of anterior lobe	4.2	4.4
Length of genal spines	2.0	

Sphaerocoryphe arachniformis sp. nov. differs from all other described members of the genus in having the inflated lobe of the glabella more oblate and with fewer tubercles, in having pitted cheeks with smooth borders, and in having a longer glabella and eyes that are farther forward. *S. unicus* Thompson, from the Caradoc of England, has the anterior lobe not only flattened laterally but produced anteriorly and dorsally; it also has pitted cheeks with smooth borders, but it has also three spines on each of the lateral margins. The closest American species is *S. robustus* Walcott from Trenton Falls, New York.

Horizon and locality: Kimmswick limestone near Glen Park and Sulphur Springs, Missouri; near Batchtown, Illinois.

Family PHACOPIDAE Corda

Subfamily DALMANITINAE Reed

Genus DALMANITES Barrande

The genotype was described by Bronn as *Trilobus caudatus* from the Silurian of Gottland. The same type occurs in the Ordovician and Silurian of England from the lower Llandeilo Flags to the Upper Ludlow, and is well described and figured by Salter.[1] A specimen from Gottland was figured by Angelin as *Phacops caudata* Brünn,[2] which closely resembles the specimens described by Salter as variety *a*. In the absence of a figure with the original description, the illustration given by Angelin has been taken by the writer as a basis for generic diagnosis. Comparing this specimen with the clearly congeneric specimens figured by Salter, it is evident that *Dalmanites* is highly variable in regard to the length of the caudal extension. A mucronate posterior extension of the pygidium can be considered normal for the Silurian and Devonian representatives of the genus, but is not invariably present.[3] The more important characteristics of this

[1] *Mem. Geol. Surv. United Kingdom,* II (1849), 1, Pl. 1, Figs. 1–12, 15.

[2] *Palaeontologica Scandinavica,* Part I, Pl. 8, Figs. 2 *a–c*.

[3] See Salter, *loc. cit.,* Fig. 15.

genus were pointed out by Emmrich and Beecher and consist of a glabella with three well-marked lateral furrows, genal angles produced into long spines, large prominent eyes with many distinct facets, triangular pygidium with more than eleven segments. The pygidium may or may not be pointed or mucronate.

Dalmanites achates Billings, a common species in Ordovician rocks of North America, agrees with the genotype in the lobation of the glabella, character of the eyes, shape and segmentation of the pygidium, but lacks the caudal spine. This species and *Dalmanites katharina* sp. nov. from the Kimmswick limestone are clearly forerunners of the typical Silurian *Dalmanites,* although they lack the specialized mucronate pygidium, and should be classed with that genus.

DALMANITES KATHARINA sp. nov.

PLATE XXX, FIGURES 19–28

Cephalon broadly sublunate to subquadrate in outline, with the genal angles produced into long, slender, pointed spines; surface depressed convex. Glabella large, rapidly expanding anteriorly until somewhat more than twice as wide at the front margin as at the occipital furrow; gently convex, with the greatest elevation in the posterior portion of the anterior lobe. Dorsal furrows rounded, well marked, curving rapidly inward from points in front of the eyes to the outer ends of the posterior glabellar lobes, where they are nearest each other; from here to the posterior margin of the occipital segment they diverge slightly. Glabellar furrows well defined, opening into the dorsal furrows, deepest at their inner extremities, which in each pair are separated from each other by a space about one-half to two-thirds the length of the respective furrows. The first pair of glabellar furrows extend backward and inward in a gentle curve which is concave forward, making about a 70° angle with the axis of the cephalon. The second pair are straight or nearly so, extending somewhat forward, forming triangular lateral lobes with the anterior pair. The posterior pair are nearly transverse, gradually widening toward the median line of the glabella so that the anterior and the posterior edges of the third pair of glabellar furrows are parallel to the middle glabellar and occipital furrows, respectively. The occipital furrow is transverse, straight and very shallow in the middle, becoming slightly deflected and much deeper laterally. The middle portion of the occipital segment is highly elevated and wider than the lateral extensions. The fixed cheeks are rather highly convex, rising from the dorsal furrows to the palpebral lobes; marked posteriorly by well-defined, rather wide, and shallow marginal furrows that join the dorsal furrows proximally, narrow, and die out distally before

meeting the thickened lateral margins. A flattened ridge limits the fixed cheeks beyond the marginal furrow. The base of the genal spines rises above the general surface of the cheeks at the genal angles, is bifid, with the inner process joining the posterior cheek ridge, and the outer prong joining the thickened lateral margin. Posterior to its base, the genal spine is flattened but quickly becomes round or nearly so to the posterior extremity. In outline these spines are slightly convex outward and are always longer than the glabella.

Eyes prominent, projecting, situated on elevations opposite the second glabellar lobes about midway between the posterior and anterior margins of the cephalon. At the base of the visual surface is a well-defined, rounded groove from which the surface of the cheek slopes downward in all directions. At its base the faceted surface is lunate in outline, convex anteriorly and laterally over an arc of about 240°; projecting upward with a constantly diminishing diameter, so as to appear as a truncated cone when viewed from the antero-lateral corners of the cephalon. Facets appear as subcircular markings, are ranged en échelon in rows which encircle the visual surface diagonally. Faceted surface concave inwardly.

The facial sutures are usually obscure, but appear to originate near the distal ends of the widened anterior glabellar lobe extending in almost straight lines to the inner margin of the eye, following around the eye groove and extending outward and backward in a curve which is gently concave backward, to cut the lateral margins just above the outer projection of the base of the genal spine. The surface of the glabella is covered with small scattered pustules; cheeks finely granulose.

Pygidium triangular in outline; antero-lateral margins well rounded, posterior extremity very sharp; transversely highly convex with the axial lobe rising higher than the pleural lobes. Axial lobe sharply defined for about four-fifths of its length, tapering gradually to a rounded point posteriorly, with from thirteen to fourteen well-marked annulations which gradually narrow posteriorly. In large specimens from 16 to 18 rings can be counted. Pleural lobes broader and less convex than axial lobes, ribs separated by well-marked grooves, and corresponding in number to the segments of the axial lobe. The pleurae are almost perpendicular to the axial furrows anteriorly, but posteriorly make smaller angles with the axis until the last pair are almost parallel. The pleural ribs are distinctly marked at their inner ends, but are weakly defined at the lateral margins. Lateral margins have a tendency to concavity in mature specimens. Surface of the pygidium smooth with a few scattered tubercles on the axial lobe.

The hypostoma associated with this species is subelliptical in outline, ending posteriorly in a point; anterior margin broadly rounded with sides produced into short auriculate appendages. Surface moderately convex, with the greatest elevation near the anterior margin, gradually descending to the posterior point, and more abruptly to the lateral margins. The central body comprises most of the hypostoma and is separated from the thickened postero-lateral margins by a well marked narrow furrow. This furrow joins the lateral margins somewhat in back of the middle of the hypostoma. A short distance above these points, two lateral furrows which are slightly concave posteriorly cross the middle of the hypostoma transversely. These furrows are not as deep as the posterior furrows and their inner ends are separated by a distance equal to the length of one lateral furrow.

MEASUREMENTS

	Millimeters	
Length of cephalon	6.6	7.4
Width of cephalon	12.0	16.0
Distance between eyes	8.0	8.8
Width of pygidium	12.0	12.4
Length of pygidium	8.3	10.8
Length of hypostoma	5.0	5.0
Width of hypostoma	5.4	5.6

Dalmanites katharina sp. nov. is closely related to *D. achates* Billings, with which it agrees in general outline and proportions. The former has shorter, higher, and more projecting eyes than the latter, longer genal spines, with a more prominent shoulder at their bases and a more triangular pygidium with pleural ribs tending to obsolescence at the margins.

Horizon and locality: This species is abundant in the Kimmswick limestone at Glen Park and Sulphur Springs, Missouri, and near Batchtown, Calhoun County, Illinois.

Subfamily PTERYGOMETOPINAE Reed

Genus PTERYGOMETOPUS Schmidt

PTERYGOMETOPUS CALLICEPHALUS (Hall)

PLATE XXIX, FIGURES 36–39

Phacops callicephalus Hall, *Pal. New York,* I (1847), 247, Pl. 65, Figs. 3, *a–i.*

Pterygometopus callicephalus Clarke, *Geol. Minnesota,* III, Part II (1894), 731, Figs. 51–52; p. 732. Weller, *Geol. Surv. New Jersey, Pal.,* III (1903), 206, Pl. 15, Figs. 29–32.

For full bibliography see Bassler, *Bull. 92 U.S.N.M.*

This species is plentifully represented in the Kimmswick limestone and has been found at nearly all localities. Although the original descrip-

tion and illustrations do not clearly define this species, comparison with material from the typical locality at Middleville, New York, leaves no doubt as to the identity of the specimens from Missouri and Illinois. *Pterygometopus* is best represented by two well-defined species in rocks of Trenton age, *P. callicephalus* and *P. intermedius*. The latter can easily be separated from the former because the first glabellar furrows are convex rather than concave anteriorly. A third species, *P. schmidti* Clarke agrees closely with *P. callicephalus* except that instead of possessing well-rounded genal angles, the cheeks are produced into short, round spinules. Many cranidia have been collected in the Kimmswick limestone and all agree closely with *P. callicephalus*. None show the anteriorly convex first glabellar furrows of *P. intermedius*. A few small cephalons collected near Batchtown, Illinois, have genal angles that lack the well-rounded outline of the typical specimens, and in some cases may be considered to possess very short incipient spines. In all other regards they closely resemble *P. callicephalus*. The spines are not so well developed as those shown by Clarke in illustration of *P. schmidti;* but they are of the same nature. The largest cephalon of this kind is 9.5 mm. in length and 15.2 mm. in width, while the average is 6 mm. long and 10.8 mm. wide. An average mature cephalon of the normal type is 11.4 mm. long and 22 mm. wide. Aside from the generally smaller size, the spinose variety shows by its less deeply incised glabellar furrows the probable immaturity of its development. The presence or absence of genal spines is at best a doubtful basis for specific distinctions; in this case it appears certain that the tendency to spinose projections of the cheeks is associated in a few examples with the youthful stages of development. Since all of the immature specimens do not show this tendency, short spines at the genal angles may have some significance as a secondary sexual character associated with the adolescent stage in the ontogeny of the species. At any rate, the presence of *P. schmidti* Clarke in the Kimmswick fauna cannot be postulated on this basis alone.

The pygidia associated with these heads all have from 8 to 10 axial annulations and from 5 to 6 bifurcating pleural ribs. This bifurcation begins at the inner ends of the pleural segments as in the typical *P. calicephalus*. The pleurae do not extend for one fourth their length as simple ribs as in *P. schmidti*. On specimens in which the test is preserved the ribs extend well to the lateral margins.

In a specimen collected at a locality one-quarter mile north of Sulphur Springs, Missouri, a cephalon of *Pterygometopus callicephalus* was found about half an inch from a well-preserved phacopid hypostoma. This hypostoma resembles that of *P. atavus* (Barrande) from Stage D of the Bohemia section in its major features, and due to its close association

with the cephalon of *P. callicephalus,* can be referred with some degree of certainty to that species. A similar hypostoma was found in the Kimmswick of Calhoun County, Illinois, where *P. callicephalus* is also well represented numerically. The general outline of this hypostoma is subquadrate, enlarged a little anteriorly, broadly rounded posteriorly. The anterior margin is gently convex forward, produced laterally into short, sharp, auriculate appendages. The central body is surrounded laterally and posteriorly by a margin which is flat and narrow anteriorly, becoming wider and very concave posteriorly. The central body joins the front margin directly, without an intervening depressed area, is highly convex and cut by two gashlike furrows which originate at the antero-lateral angles and extend backward and inward until obsolete about two-thirds of the length of the central body from the front margin. In this way ridgelike postero-lateral lobes are isolated on the central body. These lobes turn back in arrowhead fashion, merging with the general elevated surface of the body at their inner ends, and with the posterior convexity behind. Length, 5.4 mm., width at anterior margin, 6 mm.

Horizon and locality: Trenton of New York, Ontario, Manitoba, Kentucky, New Jersey, Minnesota, etc.; Kimmswick limestone near Batchtown, Illinois, Ralls, Pike, and Jefferson counties, Missouri.

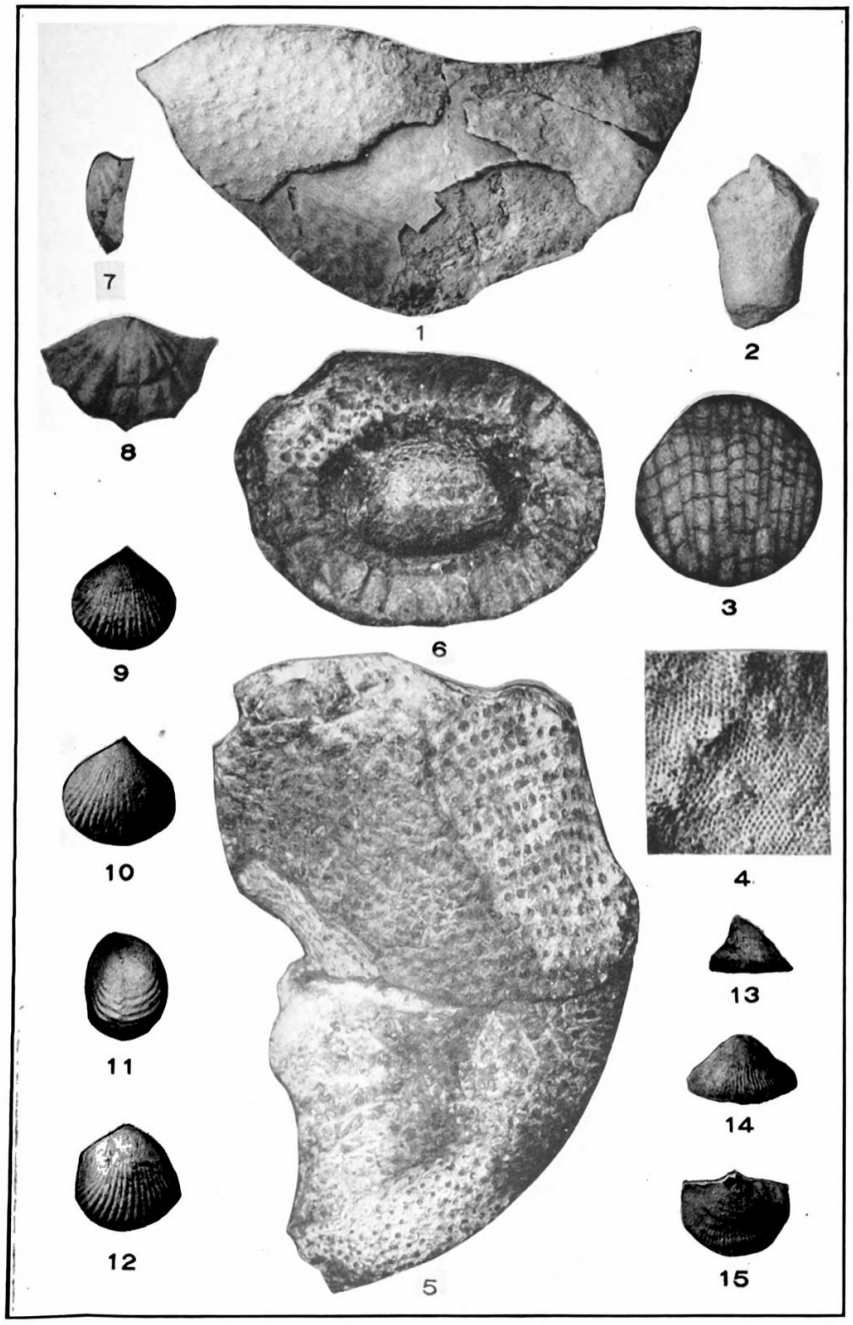


PLATE XXIII

FIGS. 1, 4.—*Escharopa patens* Bradley (p. 223). 1. Nearly complete zoarium, holotype; Glen Park, Missouri, W.M. 10777. 4: Portion of zoarium, ×3.5; near Batchtown, Illinois.

FIGS. 2–3.—*Hallopora gigantea* Bradley (p. 222). Fragment of zoarium, holotype, and vertical section, ×10; near Batchtown, Illinois, W.M. 29124.

FIGS. 5–6.—*Receptaculites cornutiformis* Bradley (p. 221). Lateral view and section of holotype; Glen Park, Missouri, W.M. 21717.

FIGS. 7–8.—*Mcewanella raymondi* Foerste (p. 224). Side and pedicle views of plesiotype; O'Flynn Mine, Independence County, Arkansas, W.M. 29095.

FIGS. 9–12.—*Anastrophia primigenia* Bradley (p. 228). 9–11: Pedicle, brachial, and lateral views of holotype. 12: Brachial view of paratype; O'Flynn Mine, Independence County, Arkansas, W.M. 10716.

FIGS. 13–15.—*Clitambonites diversus* (Shaler) (p. 227). Lateral, front, and pedicle views of a complete pedicle valve, plesiotype; near Glen Park, Missouri, W.M. 29046.

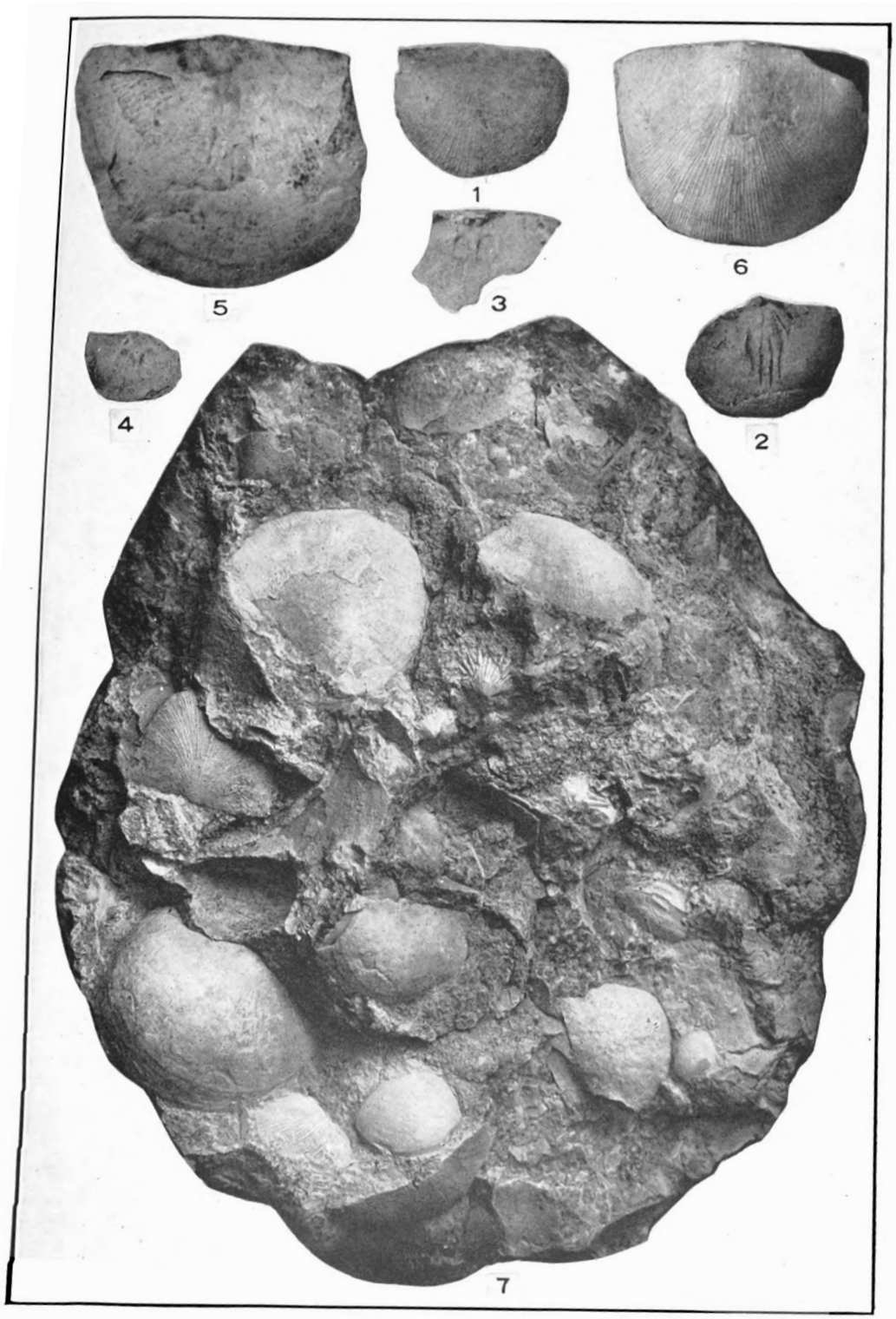


PLATE XXIV

FIGS. 1–6.—*Rafinesquina jeffersonensis* Bradley (p. 225). 1–4: Pedicle valve and interior views of one pedicle and two brachial valves, cotypes; near Glen Park, Missouri, W.M. 28990. 5–6: Two large pedicle valves, paratypes; near Batchtown, Illinois, W.M. 28997 and 28991.

FIG. 7.—Slab of Kimmswick limestone showing characteristic abundance of brachiopods, in the lower part of the formation; near Batchtown, Illinois, W.M. 28992.

PLATE XXV

FIG. 1.—*Pterotheca triangularis* Bradley (p. 242). Dorsal view of holotype; Glen Park, Missouri, W.M. 20705.

FIGS. 2–3.—*Gyronema intermedium* Bradley (p. 238). Front and spiral views of holotype; Glen Park, Missouri, W.M. 5897.

FIGS. 4–5.—*Bucania batchtownensis* Bradley (p. 234). Dorsal and umbilical views of holotype; Glen Park, Missouri, W.M. 5903.

FIGS. 6–9.—*Holopea missouriensis* Bradley (p. 239). 6–7: Front and spiral views of holotype; W.M. 5899. 8–9: Lateral and spiral views of paratype; Glen Park, Missouri, W.M. 5898.

FIGS. 10–11.—*Tryblidium rugosum* Bradley (p. 234). Lateral and dorsal views of holotype; Glen Park Missouri, W.M. 5902.

FIG. 12.—*Conularia trentonensis occidentalis* Bradley (p. 242). Dorsal view of holotype; near Imperial, Jefferson County, Missouri, W.M. 29083.

FIG. 13.—*Hyolithes multicinctus* Bradley (p. 240). Dorsal view of holotype; Glen Park, Missouri, W.M. 5916.

FIGS. 14–17.—*Conocardium limatulum* Bradley (p. 231). Two left valves, one right valve, and posterior view showing median fringe, ×1.5, cotypes; near Batchtown, Illinois, W.M. 29052.

FIG. 18.—*Cyrtodonta sulcata* Bradley (p. 231). Right valve, holotype; near Glen Park, Missouri, W.M. 20711.

FIG. 19.—*Ctenodonta concinna* Bradley (p. 229). Left valve, ×2.4, holotype; near Batchtown, Illinois, W.M. 20968.

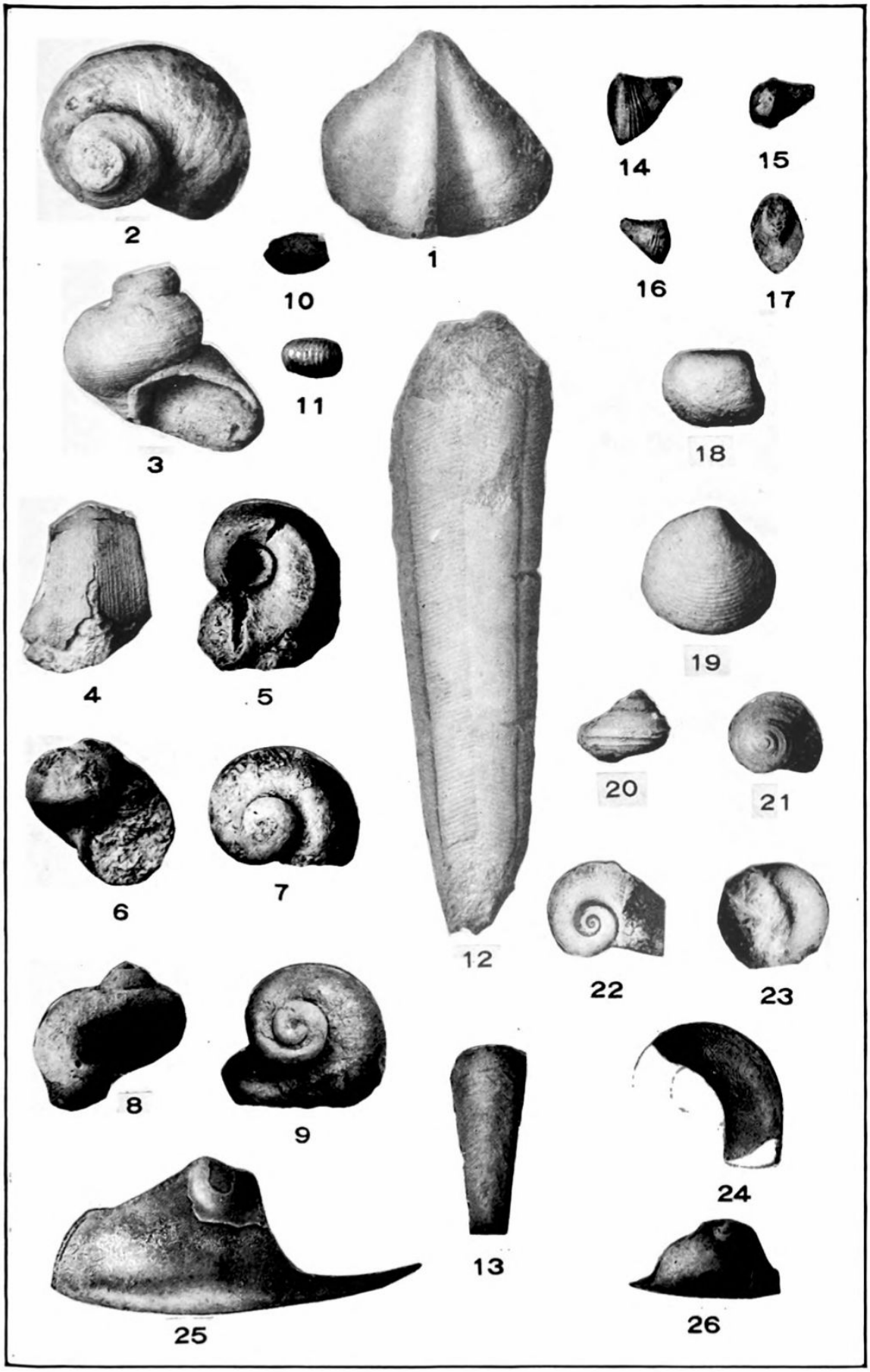
FIGS. 20–21.—*Lophospira lineata* Bradley (p. 237). Lateral and spiral views of holotype; Glen Park, Missouri, W.M. 29076.

FIG. 22.—*Phragmolites multinotatus* Bradley (p. 237). Umbilical view of holotype; Glen Park, Missouri, W.M. 5905.

FIGS. 23–24.—*Bucania punctifrons primaeva* Bradley (p. 236). Spiral views of holotype, natural size and ×3.5; near Batchtown, Illinois, W.M. 29072.

FIG. 25.—*Isotelus gigas* DeKay (p. 248). Free cheek; near Batchtown, Illinois, W.M. 28871.

FIG. 26.—*Isotelus maximus* Locke (p. 248). Free cheek with spine, near Batchtown, Illinois, W.M. 28872.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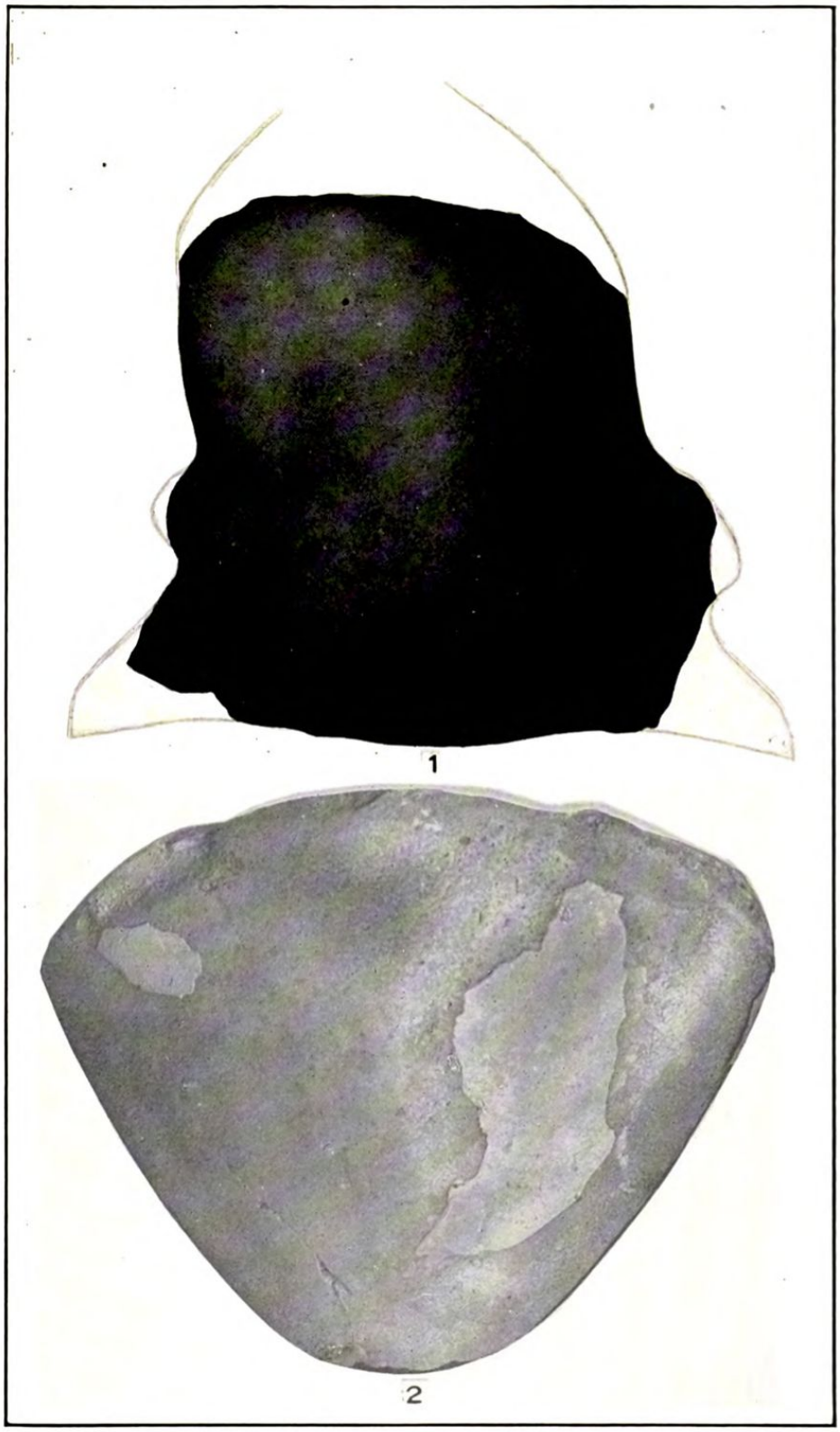

PLATE XXVI

FIGS. 1–2.—*Isotelus gigas* DeKay (p. 248). Large cranidium and pygidium, Glen Park, Missouri, W.M. 28869.

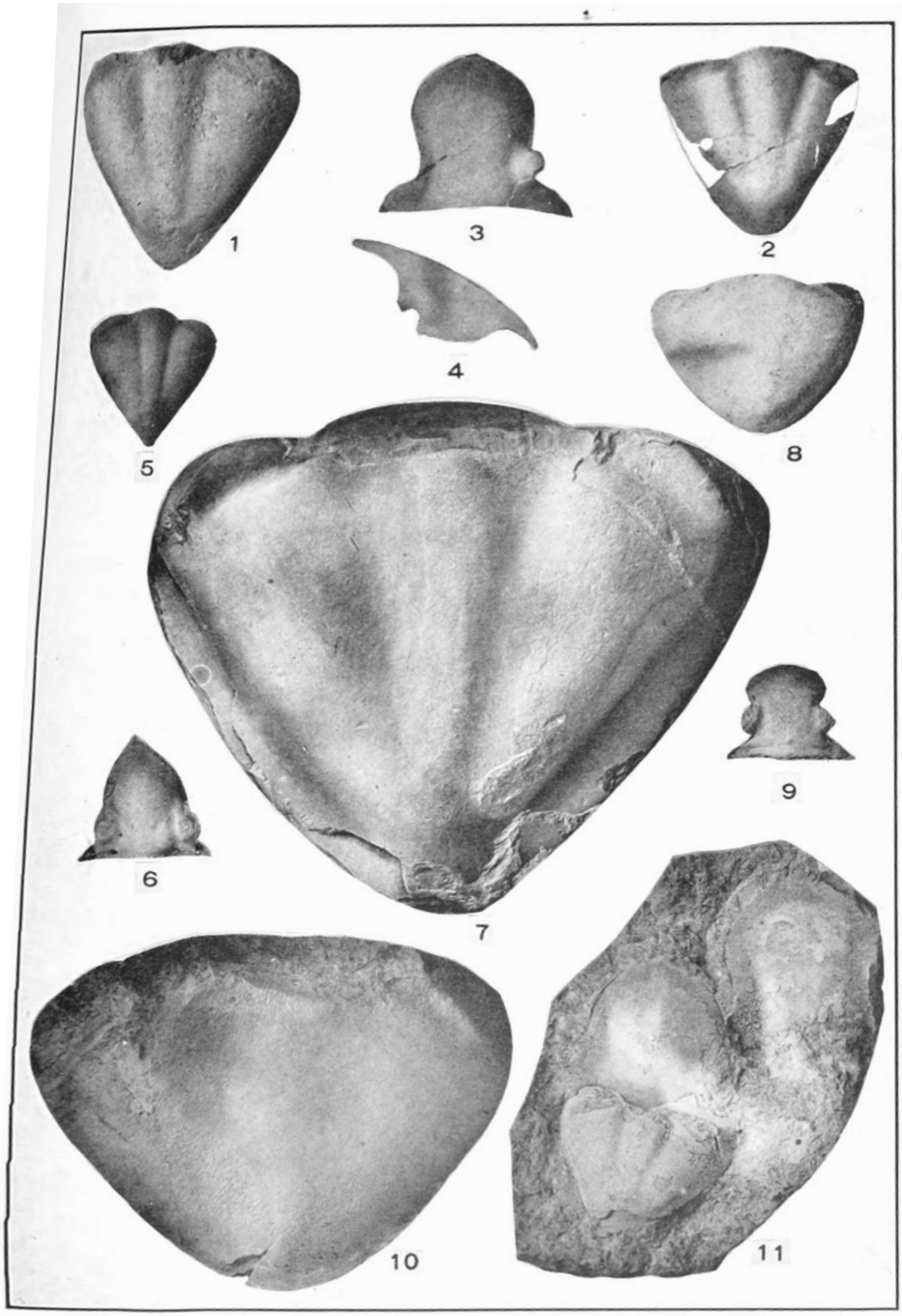

PLATE XXVII

FIGS. 1–4, 11.—*Isoteloides kimmswickensis* Bradley (p. 249). 1, 4: Pygidium, W.M. 28853, and complete fight free cheek, W.M. 28851, paratypes; Glen Park, Missouri. 2–3: Pygidium, W.M. 28855, and cranidium, W.M. 28844, paratypes; near Batchtown, Illinois. 11: Slab showing association of cranidia and pygidium, holotype; Glen Park, Missouri, W.M. 28851.

FIGS. 5–7.—*Isoteloides homalonotoides* (Walcott) (p. 249). 5–6: Pygidium and cranidium, cotypes; W.M. 12324. 7: Large pygidium, doubtfully referred to this species; W.M. 12326. All from Trenton limestone, near East Dubuque (Dunleith), Illinois.

FIGS. 8–10.—*Homotelus laeviurus* Raymond (p. 249). 8: A perfect pygidium; W.M. 28860. 9: Cranidium showing median tubercle; W.M. 28861. 10: Large pygidium, all plesiotypes; near Batchtown, Illinois, W.M. 20739.

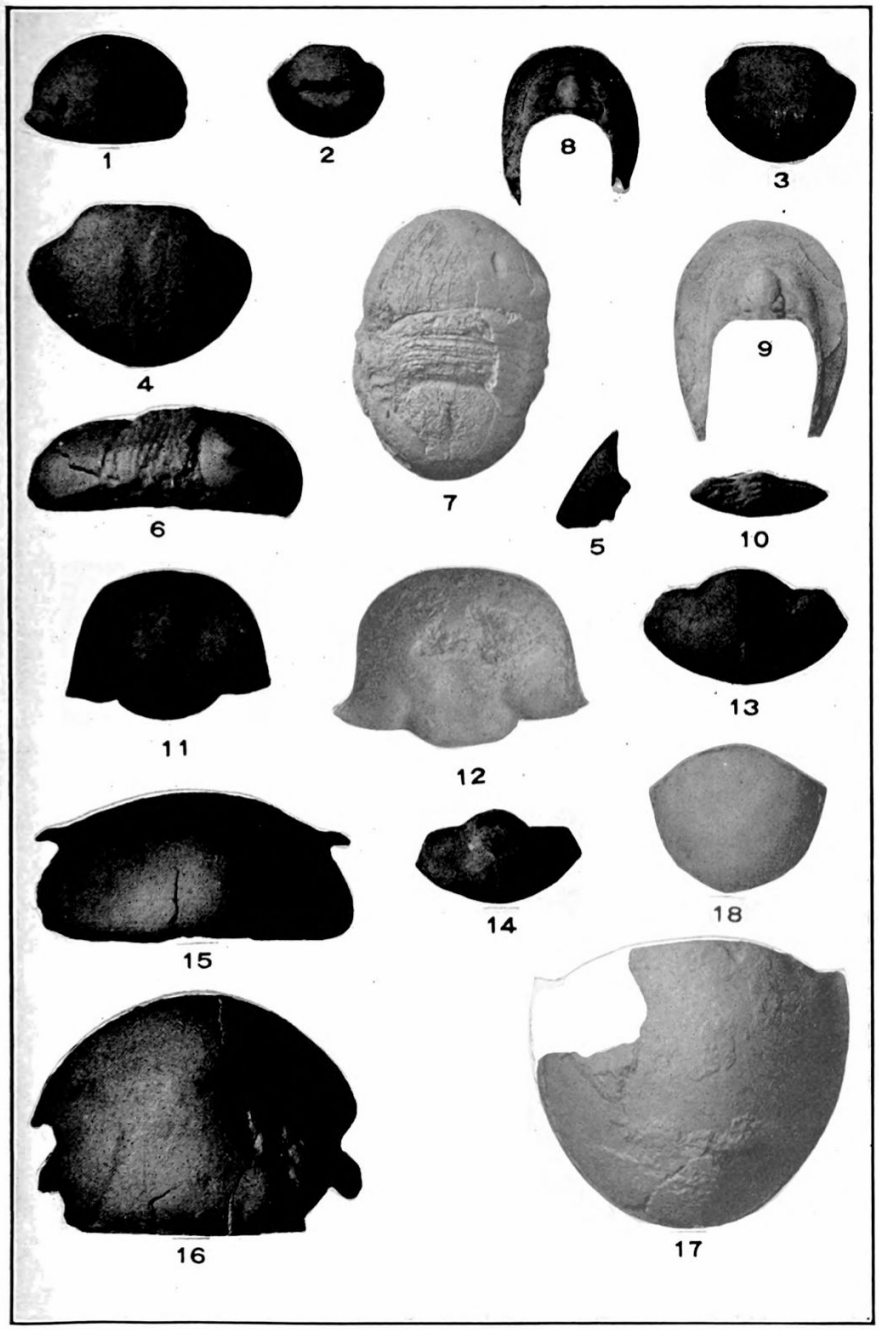

PLATE XXVIII

FIGS. 1–7.—*Bumastus billingsi* Raymond and Narraway (p. 254). 1, 4: Nearly complete cranidium and complete pygidium, plesiotypes; near Batchtown, Illinois, W.M. 20700. 2–3: Two pygidia; W.M. 20710, 5: Free cheek showing part of visual surface of the eye; W.M. 5858. 6–7: Lateral and dorsal views of an entire individual, plesiotypes; from Glen Park, Missouri, W.M. 10766.

FIGS. 8–10.—*Eoharpes uniserialis* Raymond (p. 244). 8–9: Cephalons, plesiotypes; near Batchtown, Illinois, W.M. 20680 and 28913. 10: Pygidium, ×3; Glen Park, Missouri, W.M. 20703.

FIGS. 11–14.—*Illaenus depressicapitatus* Bradley (p. 252). 11: Cranidium, paratype; near Batchtown, Illinois, W.M. 28898. 12: Cranidium showing medial depression, holotype; Glen Park, Missouri, W.M. 28895. 13: Pygidium, allotype; near Batchtown, Illinois, W.M. 20701. 14: Pygidium, paratype; between Sulphur Springs and Glen Park, Missouri, W.M. 28897.

FIGS. 15–18.—*Bumastus rowleyi* Foerste (p. 253). 15–17: Anterior and dorsal views of large cranidium and large pygidium, plesiotypes; near Batchtown, Illinois, W.M. 20702. 18: Small pygidium, plesiotype; Glen Park, Missouri, W.M. 28883.

PLATE XXIX

FIGS. 1–9.—*Acrolichas cucullus* (Meek and Worthen) (p. 264). 1–2: Dorsal and side views of fragmentary cranidium. 5: Pygidium, plesiotypes; Glen Park, Missouri, W.M. 5865. 3: Nearly complete cranidium showing fixed cheeks; W.M. 28921. 4: Pygidium, W.M. 20681. 6: Hypostoma; W.M. 20676. 7: Free cheek; W.M. 20673. 8–9: Dorsal and side views of a large cranidium; W.M. 20714, plesiotypes; near Batchtown, Illinois.

FIG. 10.—*Acrolichas* (?) sp. (p. 264). Portion of a glabella showing large pustules; near Batchtown, Illinois, W.M. 28940.

FIGS. 11–15.—*Acrolichas aspratilis* Bradley (p. 265). 11: Portion of large cranidium, paratype; near Batchtown, Illinois, W.M. 20674. 12: Large pygidium probably referable to this species; Cape Girardeau, Missouri, W.M. 10771. 13: Pygidium, paratype; Glen Park, Missouri, W.M. 28937. 14–15: Dorsal and lateral views of holotype, showing fixed cheeks; Glen Park, Missouri, W.M. 10775.

FIG. 16.—*Acrolichas antiquarius* Bradley (p. 268). Dorsal view of holotype; Glen Park, Missouri, W.M. 28933.

FIGS. 17–21, 24.—*Hemiarges bartoni* Raymond (p. 270). 17: Dorsal view of cranidium, ×1.5; W.M. 28943. 20: Cast of pygidium, ×1.5; W.M. 5871, plesiotypes; Glen Park, Missouri. 18–19: Two cranidia; W.M. 20697. 21: Small cranidium, ×3; W.M. 20716. 24: Cranidium, plesiotypes; near Batchtown, Illinois, W.M. 28935.

FIG. 22.—*Hemiarges leviculus* Bradley (p. 271). Dorsal view of one of the cotypes, ×3; near Batchtown, Illinois, W.M. 28942.

FIGS. 23, 29.—*Haploconus tumidus* Bradley (p. 263). 23: Dorsal view of holotype, ×3; Glen Park, Missouri, W.M. 28916. 29: Dorsal view of small cranidium, ×3.5; near Batchtown, Illinois, W.M. 20717.

FIGS. 25–26.—*Acrolichas subdisjunctus* Bradley (p. 267). 25: Dorsal view of cranidium, paratype; near Batchtown, Illinois, W.M. 20677. 26: Dorsal view of holotype; near Sulphur Springs, Missouri, W.M. 28934.

FIG. 27.—*Cyphaspis globosus* Bradley (p. 262). Dorsal view of holotype, ×3; near Batchtown, Illinois, W.M. 20679.

FIG. 28.—*Proëtus canalis* Bradley (p. 261). Dorsal view of holotype; Glen Park, Missouri, W.M. 28922.

FIGS. 30–33.—*Goldius slocomi* Bradley (p. 257). 30: Dorsal view of holotype; W.M. 10774. 31: Plaster cast of a nearly complete pygidium; Glen Park, Missouri, W.M. 5879. 32: Small pygidium; W.M. 20686. 33: Hypostoma doubtfully referred to this species; near Batchtown, Illinois, W.M. 29057.

FIGS. 34–35.—*Encrinurus trentonensis* Walcott (p. 272). 34: Pygidium from Trenton limestone; Grant County, Illinois, W.M. 12321. 35: Lateral view of pygidium; near Batchtown, Illinois, W.M. 28964.

FIGS. 36–39.—*Pterygometopus callicephalus* (Hall) (p. 288). 36–38: Dorsal and side views of cephalon and dorsal view of pygidium; near Batchtown, Illinois, W.M. 28970. 39: Hypostoma, ×2; near Sulphur Springs, Missouri, W.M. 28971.

FIGS. 40–41.—*Calymene senaria* Conrad (p. 273). Lateral and dorsal views of cephalon; near Batchtown, Illinois, W.M. 20687.

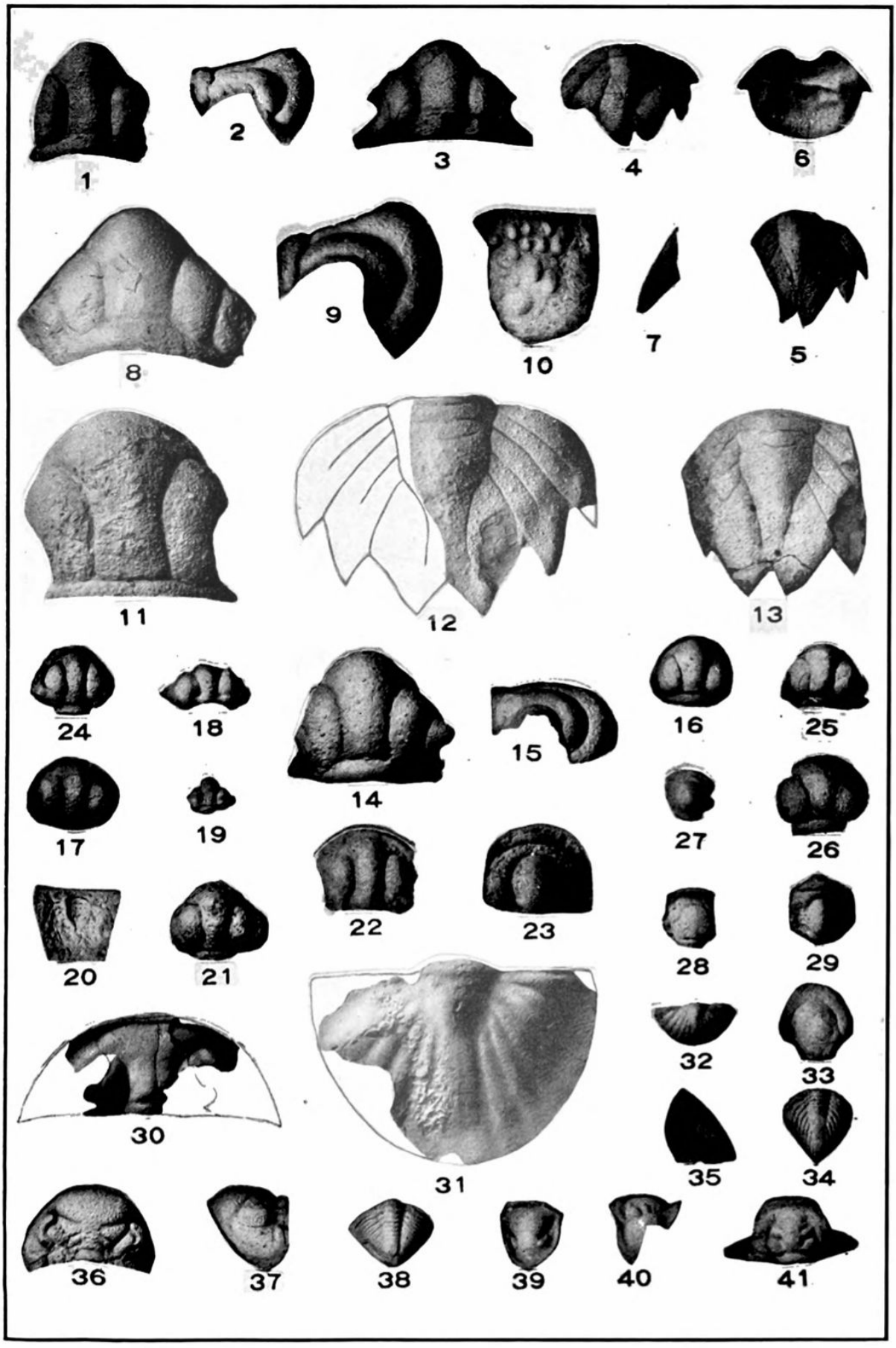
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PLATE XXX

FIGS. 1–2.—*Sphaerocoryphe arachniformis* Bradley (p. 284). Dorsal and lateral views of holotype; near Batchtown, Illinois, W.M. 20689.

FIG. 3.—*Heliomera raymondi* Bradley (p. 282). Dorsal view of a perfect cranidium, ×3.5, holotype; Batchtown, Illinois, W.M. 20692.

FIGS. 4–9.—*Remopleurides missouriensis* Foerste (p. 246). 4–7: Dorsal and lateral views of cranidium, dorsal and lateral views of free cheek with spine, plesiotypes; near Batchtown, Illinois, W.M. 28906. 8: Dorsal view of complete free cheek, showing eye and spine; near Sulphur Springs, Missouri, W.M. 29102. 9: Hypostoma, dorsal aspect, ×2; near Batchtown, Illinois, W.M. 29107.

FIG. 10.—*Ceraurus* (?) sp. (p. 283). Pygidium of uncertain affinity, ×2; near Batchtown, Illinois, W.M. 29056.

FIGS. 11–13.—*Holia magnaspina* Bradley (p. 281). 11–12: Dorsal and lateral views of a plaster cast from the natural mold of the holotype, showing large occipital spine. 13: Nearly complete cranidium, lacking the occipital spine but showing place of attachment, genotype-holotype; near Batchtown, Illinois, W.M. 20688.

FIG. 14.—*Ceraurinus tenuisculptus* Bradley (p. 278). Dorsal view of holotype; near Batchtown, Illinois, W.M. 20691.

FIGS. 15–16.—*Thaleops ovatus* Conrad (p. 256). Dorsal and anterior views of a nearly complete specimen, plesiotype; near Batchtown, Illinois, W.M. 6900.

FIGS. 17–18.—*Pseudosphaerexochus subcircularis* Bradley (p. 279). 17: Dorsal view of holotype; Glen Park, Missouri, W.M. 28949. 18: Portion of cranidium, showing fixed cheek, paratype; near Batchtown, Illinois, W.M. 28950.

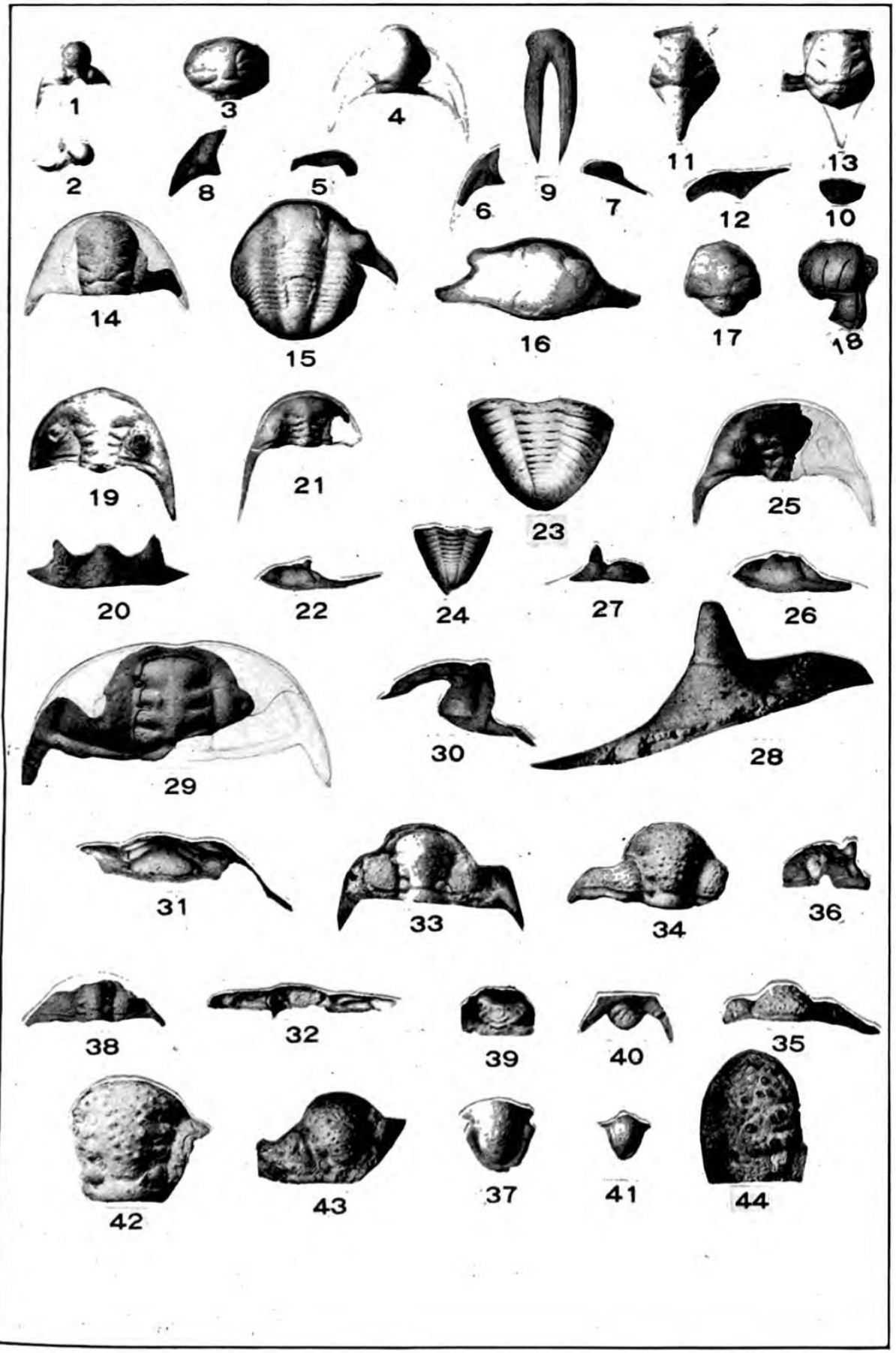
FIGS. 19–28.—*Dalmanites katharina* Bradley (p. 286). 19–20: Dorsal and anterior views of holotype, ×2; near Batchtown, Illinois, W.M. 20685. 23: Dorsal view of pygidium, ×2, paratype; Glen Park, Missouri, W.M. 28977. 21–22, 25–26: Dorsal and lateral views of two cephalons, showing genal spines. 24: Dorsal view of pygidium. 27–28: Lateral views of free cheek, showing visual surface of eye, natural size and ×3.5, paratypes; near Batchtown, Illinois, W.M. 33780.

FIGS. 29–32, 37.—*Ceraurinus platycanthus* Bradley (p. 276). 29–31: Dorsal, lateral, and anterior views of holotype; near Batchtown, Illinois, W.M. 20694. Collected by Professor A. D. Hole. 32: Thoracic segment, showing axial and distal portions of pleurae. 37: Hypostoma, paratypes; near Batchtown, Illinois, W.M. 20693.

FIGS. 33–36, 38–42.—*Ceraurus globulobatus* Bradley (p. 274). 33: Nearly complete cranidium; Glen Park Station, Missouri, W.M. 28956. 34–36: Dorsal, anterior, and lateral views of holotype. 41: Hypostoma, paratype; Glen Park, Missouri, W.M. 20709. 38–40: Nearly complete cranidium and two pygidia, paratypes; W.M. 20695. 42: Portion of large cranidium, paratype; near Batchtown, Illinois, W.M. 20719.

FIG. 43.—*Ceraurus pleurexinthemus* Green (p. 273). Fragment of cranidium; near Batchtown, Illinois, W.M. 28951.

FIG. 44.—*Ceraurus* sp. ind. (p. 276). Plaster cast from natural mold, showing fragment of glabella with large pustules; near Batchtown Illinois, W.M. 28947.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